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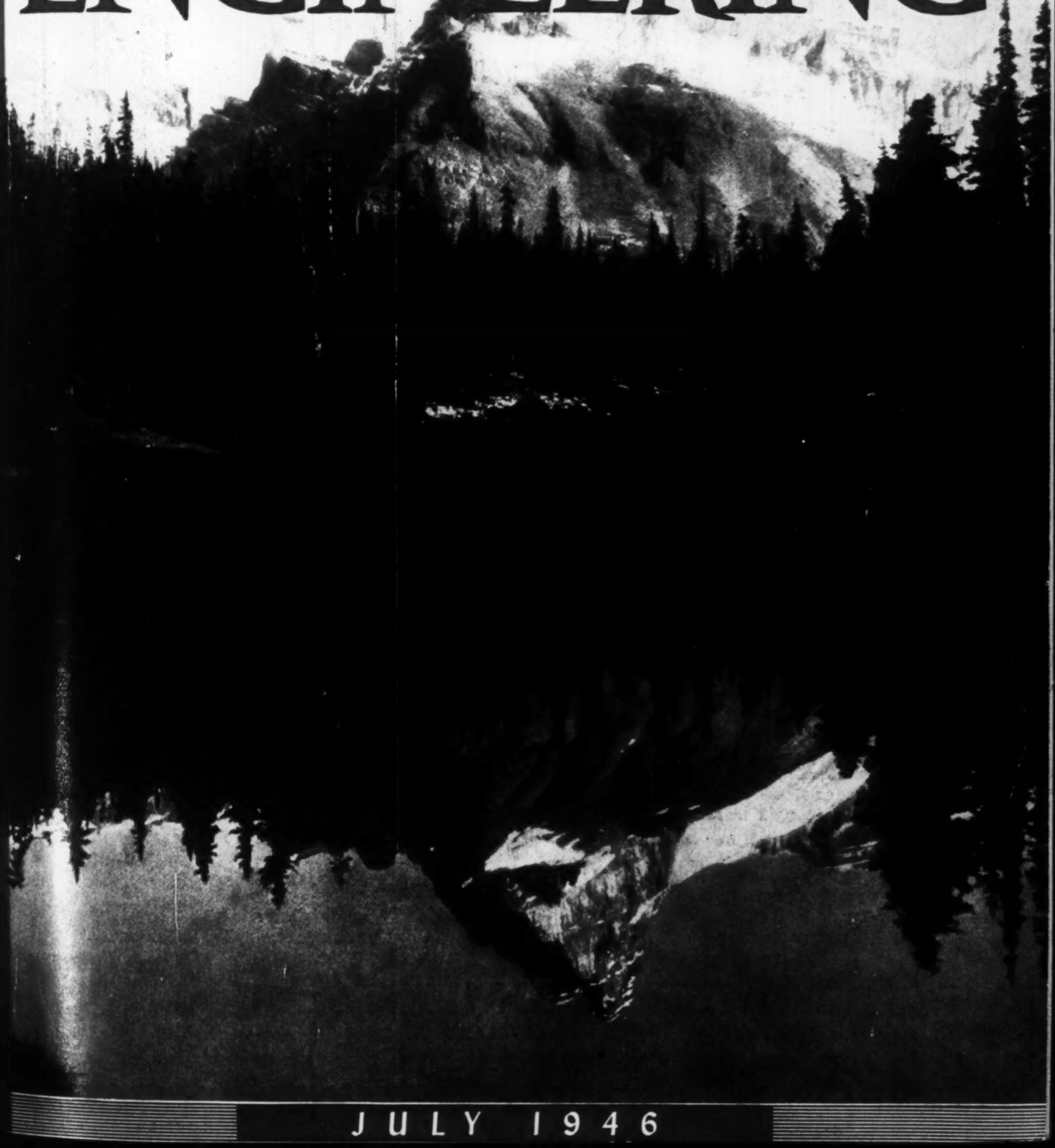

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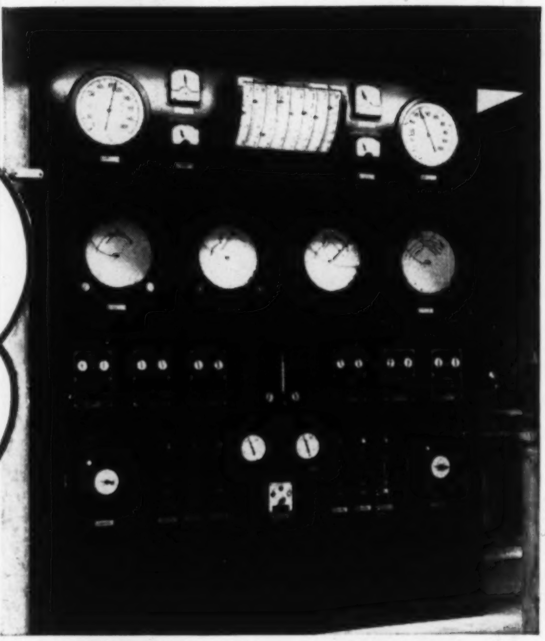
TIPS ON HOW TO SELECT BOILER CONTROL



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MECHANICAL ENGINEERING

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Contents for July, 1946

THE COVER . . . . *Photograph by A. G. Christie*
AIR TRANSPORTATION AND WORLD UNDERSTANDING . . . . . *J. P. Van Zandt* 605
MILLING-CUTTER DESIGN FOR CONTINUOUS PRODUCTION . . . . . *A. A. Schwartz* 608
AN INTRODUCTION TO ROCKETS AND JET PROPULSION . . . . . *G. E. Pendray* 611
A LIQUID-PROPELLANT ROCKET MOTOR . . . . *Lovell Lawrence, Jr.* 615
QUENCHING-WATER REQUIREMENTS OF INDUCTION-HEATED PARTS . . . *B. R. Miller* 617
FUSION-WELDED BOILER ON D.&H. LOCOMOTIVE . . . . . . *G. S. Edmonds* 619
LOCOMOTIVE BOILERS—WELDED CONSTRUCTION . . . . . . *James Partington* 622
PROSPECTIVE USE OF FUSION-WELDED LOCOMOTIVE BOILERS . . . . *J. M. Hall* 624
LIMITS OF FACTORS OF SAFETY IN THE HUMAN BODY . . . . . . *E. F. DuBois* 625
APPLYING BIOMECHANICS TO AIRPLANES . . . . *F. K. Teichmann* 628
PRINCIPLES INVOLVED IN PROSTHETIC DEVICES . . *F. P. Kreuz and H. H. Montgomery* 630
PROBLEMS IN DESIGN OF PROSTHETIC DEVICES . . . . *E. F. Murphy* 632
STEPS IN THE LOST-WAX PROCESS OF PRECISION CASTING 637
FOOD SERVICE FOR WORKERS 640
TOWARD A SCIENCE OF SOCIAL SELF-CONTROL . . . . . . *Dorwin Cartwright* 643

EDITORIAL 603
BRIEFING THE RECORD 645
COMMENTS ON PAPERS 660
REVIEWS OF BOOKS 663
A.S.M.E. NEWS 668
CONTENTS OF A.S.M.E. TRANSACTIONS . 692

INDEX TO ADVERTISERS 108

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(Manufacturing methods require that the exhaust tubing and center filament support be in perfect alignment. Any variation shows up when the tube is laid in the "V" holder and rotated 360 deg.)

Volume 68
No. 7

MECHANICAL ENGINEERING

July
1946

GEORGE A. STETSON, *Editor*

Science and Life

IT is a far cry from the conditions which faced American industry when George Westinghouse entered it to manufacture his air brake and those which the companies which grew out of that courageous venture faced in 1946 on the hundredth anniversary of his birth. For the decades which intervened between then and now have been the period in which science has had its most intensive development, and in those years the world has come to realize, and in some instances to dread, the influences which science has brought to bear on society and on life in the world.

The times in which Westinghouse began his work were under the influence of the industrial revolution, then about a century old. Mechanical skills, aided by the rapid development of power and machinery, were competent for the task of manufacturing such inventions as Westinghouse and scores of others were bringing forth, based largely on mechanical principles. Physical elements that the eye could see and the hand could touch—cylinders, pistons, cranks, rods, gears, belts, and the like—were being combined in countless ways to do the world's work and raise the standard of living. An intelligent mechanic could follow motions, even in complicated mechanisms, easily enough to understand what was going on. Even the application of compressed air that could not be seen was intelligible to men who knew about the expansive force of steam or who had been familiar with hydraulic devices in which water was transmitted or used as the activating element. Even if the craftsman's knowledge of analytical mechanics or the mechanics of materials was limited, intuition, experience, and trial and error were useful aids to attainment of desired results.

During this period, however, the uses of electricity were being developed and men like Westinghouse were manufacturing machinery for the generation, transmission, and use of electrical energy. The Niagara Falls development, for example, marked the end of an epoch when men thought in terms of local concentrations of the generation and use of power and of the exclusive use of mechanical, hydraulic, and pneumatic devices for its transmission, and turned to electricity as providing a more economical and versatile method. Faraday and others, working in the fields of pure and applied science, had introduced a new element into the machinery industries—something that could not be seen or handled; and for the design of machinery using this new element mathematical relationships could be computed to predict in advance what the electrical characteristics should be. Applied science rapidly replaced rule of thumb and technology itself was enormously enriched. The products of industry grew in number and importance, and life in the world became dependent on and profoundly influenced by them. Once more the standard of living was raised.

The three-day forum of the George Westinghouse Educational Foundation devoted to the theme "Science and Life in the World," held at Pittsburgh, May 16–18, 1946, in connection with the centennial anniversary of the birth of George Westinghouse, has marked, in a manner, the beginning of another epoch. The forum was held at a dramatic moment in the history of the world, at the end of a world war that had been fought as a battle between scientists, that had been won by the combined resources of pure and applied science and technology, and that had roused the public mind to an appreciation and a fear of these powerful forces. For science, unnoted by the public in general, had, for generations, been quietly extending its knowledge and its power. In hundreds of laboratories all over the civilized world, including those of the great industrial establishments, the work had been going on, bit by bit, piece by piece, to coalesce in principles useful for industry and destructive in war. As technology bowed to applied science in the decades before the war, so applied science bows now to pure science. The pure scientists whose aim is to add to the sum of man's knowledge have provided new materials for the applied scientists to work with, and the applied scientists, through developments in engineering and technology, will provide new products for the industries they serve. Through this chain does science affect life in the world.

E.J.C. Book Project

SEVERAL months ago an appeal was made in these pages for support of a project of the A.S.M.E. Committee on International Relations to restock the technical libraries of the war-devastated nations.

Since the first appeal was made the work of the A.S.M.E. Committee has been taken over by a committee of the Engineers Joint Council which is made up of the presidents in office, junior past-presidents, and secretaries of the Civil, Mining, Mechanical, Electrical, and Chemical engineering societies, so that the scope of the project has been considerably enlarged. Moreover, the E. J. C. Committee on International Relations has joined forces in its book project with the American Book Center for War Devastated Libraries, Inc., with headquarters in the Library of Congress, Washington, D. C.

According to an announcement recently made the American Book Center works closely with the Department of State and is recognized in foreign countries. It enjoys shipping privileges and priorities which facilitate deliveries abroad. UNRRA feels that the book program is so directly related to reconstruction of devastated countries that it is providing shipping space for the books. The co-operative arrangement thus solves one of the most perplexing problems which the original A.S.M.E. Committee faced—how to deliver the books it collected.

The arrangements entered into with the American Book Center do not interfere with the original plan that donors of technical books shall be able to personalize their gifts by means of a special bookplate. Bookplates from an original drawing by G. H. Kuechler will be mailed on request to persons wishing to donate books. This bookplate shows five large volumes bearing insignia of the five engineering societies represented on E.J.C., with space for names of recipient and donor "through the engineers of the United States of America."

Engineers who have technical books and periodicals to contribute to this worthy project are asked to send a list of what they have to offer to the Chairman, Book Commission, Engineers Joint Council, 29 West 39th St., New York 18, N. Y. The Commission will then send a supply of bookplates and instructions for shipping, and will be able to keep a record of its accomplishment.

Gifts of money, of which several have been received to date, will be used by the committee to purchase new books for special needs.

As a result of the original appeal for books and money, more than 100 individual offers of technical books and magazines have been received. Although shipping difficulties delayed taking immediate advantage of these offers, the arrangements entered into with the American Book Center have removed this great obstacle so that contributions are already on their way to their destinations. With a fund especially contributed for that purpose a set of recent books on management has been purchased for the Masaryk Academy in Prague.

The American Book Center for War Devastated Libraries, Inc., is sponsored by twelve of the nation's leading library groups, including the American Library Association and the associations of law, college and reference, medical, research, and children's libraries. Kenneth R. Shaffer is the executive director of the American Book Center. Work was started in February, 1945, with 20 countries originally benefiting. Recently 14 more countries were added, financed by the Rockefeller Fund. About 5000 libraries are beneficiaries.

For practical reasons donors of books must prepay the shipping costs to Washington. However, if these costs constitute a burden the donor does not feel he can bear, he may ask for a refund. The books and periodicals will be allocated to countries and institutions where they will be most helpful and donors are asked not to designate the country to receive their books.

It will be realized that the war closed regular avenues of communication. It is estimated that the libraries of half the world were destroyed. Where they were spared physical damage, they were impoverished by isolation.

The 34 countries which benefit under the E.J.C.'s joint program with the American Book Center are in two groups. The "full participants" are: Belgium, Burma, China, Finland, Greece, Italy, Luxembourg, Netherlands, Norway, Poland, Siam, and Yugoslavia. The "limited participants" are: Czechoslovakia, Denmark, England, France, Philippines, Soviet Union, Austria, Rumania, Hungary, Bulgaria, Sweden, Switzerland, Egypt, Turkey, Korea, and Germany and Japan.

Shipping facilities are limited and demand that materials be carefully selected. Emphasis is placed on publications issued during the past decade, on scholarly books which are important contributions to their fields, on periodicals of significance (even incomplete volumes, as complete volumes can be assembled by the Book Center), and on fiction and nonfiction of distinction. All subjects—history, the social sciences, music, fine arts, literature, and especially the sciences and technologies—are wanted.

What is not needed includes textbooks, out-dated monographs, recreational reading, books for children and young people, light fiction, materials of purely local interest, popular magazines, popular nonfiction of little enduring significance, and the like. Only carefully selected federal and local documents are needed and donors are asked to write directly to the Commission with regard to specific documents.

The success of the Engineers Joint Council's project to restock the technical libraries of the war-devastated and war-isolated countries of the world will depend upon the generosity of individuals to whom the appeal for books and periodicals is directed. E.J.C. has taken the initiative and has set up the mechanisms by which donations can be made most easily and the distribution of books to the libraries where they are most needed can be facilitated. The next step is to organize solicitation drives in every community of the nation where the engineers reside whose national societies are represented on the E.J.C. Possibly before this appeal reaches readers, additional appeals will be received through local channels. Before the individual engineer now lies the opportunity of sharing the surplus of his abundance with his fellow engineers of other lands where war has destroyed or isolated their libraries. The cost in time and money is insignificant. Now is the time to clear out the bookshelves, to pack up and send to the American Book Center those technical magazines that have cluttered up bookcases and table tops, too useful to throw out but infinitely more useful than nothing at all.

The Engineers Joint Council has done and is doing its part. By means of the book project it is demonstrating one of the many ways in which it can be an instrument for collective action of the engineers of the nation. If there is need for an organization national in scope and representative of many important groups of engineers, the response to this appeal for books will demonstrate how effectively it can be made to operate.

AIR TRANSPORTATION *and* WORLD UNDERSTANDING

By J. PARKER VAN ZANDT

DIRECTOR OF AVIATION RESEARCH, THE BROOKINGS INSTITUTION, WASHINGTON, D. C.

IN these fast-moving days it may be helpful to recall that old saying: "It's not what you don't know that hurts you; it's what you knows for sure that ain't so." So many things we knew "for sure" a few years ago are no longer so. Take our ideas about world geography, for instance:

A few days ago I ran into an old friend of mine at the Army and Navy Club in Washington. The last time I had heard from him he was in Tokyo, on General MacArthur's staff. "Why, Colonel," I exclaimed, "I thought you were on the other side of the Pacific." "So I was," he replied, "three days ago." In less than three days he had come on a routine Army flight via Marcus, Wake, and Johnston Islands—those tiny coral atolls in mid-Pacific which most of us had never heard of a short time ago; then Honolulu, San Francisco, and Topeka—only six intermediate stops between Tokyo and Washington.

Such a trip, of course, is not unusual today. Many of you can match it in your own experience or in that of your immediate family, or friends. A year ago our ferry pilots were delivering planes from the United States to India in three days and returning to this country in the same week. Last summer at the peak of its operations the Air Transport Command was flying over a thousand trips a week across the Atlantic.

Many flying members of the A.S.M.E. became almost as well acquainted during the war with Khartoum on the Upper Nile, or Belem at the mouth of the Amazon, as they were with their own home towns. In China planes are now a familiar sight to millions of Chinese who have never seen a locomotive or an automobile. The Chinese, by the way, had no word in their language for "airplane," so they described it as "a ricksha in the heaven that goes without a coolie." Translated into pidgin English this became: "topside ricksha coolie no have got."

THE AIR AGE IS NOW

What can we see in the international air-transport picture for the immediate postwar period? It is safe to predict, I believe, that before the end of this decade, that is, by December, 1949, the major cities of the world will be connected by a network of trunk air routes over which daily flights will operate at sustained speeds in the neighborhood of 300 miles an hour.

It requires no prophetic insight to foresee schedules of 300 miles an hour or more. Transport planes are already flying, or soon will fly, which approach or exceed this speed: The Boeing Stratocruiser, for example, developed from the B-29 Superfortress, or the Douglas Mixmaster, both of which have recently flown across the continent in about 6 hours; the Lockheed Constellation, in which TWA flew 45 passengers from Los Angeles to New York in $7^1/_2$ hours last February, and is now averaging a little over 12 hours from New York to Paris several times a week. Then, there is Republic's new Rainbow, the prototype of which has already flown and which is expected to cruise at around 400 miles an hour; and other types of aircraft.

Now, consider what daily schedules crisscrossing the globe at average speeds of 300 miles an hour will do to this world of ours: It means, for example, that you will be able to leave the capital of the United States after lunch one day and have breakfast the following morning *in any capital of any country in all of Latin America or in all of Europe*—in Paris, France, or in Rio de Janeiro, Brazil; in Moscow, or in Santiago, Chile; in Athens, or in La Paz.

This is the measure of our immediate postwar world—between lunch and breakfast; the world of the next ten years; the world you and I have got to adjust our thinking to. If you have sons or daughters starting in high school about now, this is the world they will grow up with during their school years.

As startling as this may seem, however, it is only a foretaste of what will follow: By the time your children in grade school now graduate from college, velocities *above the speed of sound* will have begun to come into commercial use. An even more *fantastic shrinkage* of the world will then begin to take place.

A few months ago, at the Wilbur Wright Memorial Lecture, I heard the distinguished jet-propulsion expert, Dr. Roxbee-Cox, describe what British scientists see in store for us two or three decades from now. There are no physical laws, he said, now known that place any ultimate limit on the speed planes may eventually attain. In research wind tunnels here and abroad, supersonic speeds up to 2000 miles an hour are already being studied. That is over twice as fast as the earth revolves in these latitudes. Sooner or later, in a decade or two at most, we will be able to travel faster than the sun travels overhead!

The limiting factor in future practicable speeds, says Dr. Cox, may prove to be the human digestive system. The problem, he said, is basically a gastronomic one. Project yourself for the moment twenty years ahead, into the year 1966: Suppose you have just finished a delicious lunch in Paris and then you step into a rocket plane bound for, say, Chicago. You will probably arrive in Chicago before the lunch hour, *Chicago* time, and, added Dr. Cox, "it is going to be frightfully hard, you know, on the human digestive system, eating two lunches the same day."

WILL THE NEW WORLD BE ANY BETTER?

There is no escaping the hard fact that the prewar world is obsolete, or at least highly obsolescent. But that does not mean, unfortunately, that the new world will necessarily be *better*. All we can say "for sure" is that it will be *different*. Certainly aviation is making the world into a neighborhood; but making people closer neighbors does not automatically make them friends. It may lead, in fact, to far more violent world quarrels than the war we have just been through.

To suppose that this country, for example, can keep the secret of atomic-bomb production indefinitely is to put our heads in the sand. The theory of atomic fission was well understood throughout the world before the war; what we did was merely to show that the theory actually works. As Norman Cousins has brilliantly said, we were not the only horse in the atomic

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Presented at the Spring Meeting, Chattanooga, Tenn., April 1-3, 1946, and at the Semi-Annual Meeting, Detroit, Mich., June 17-20, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

derby—we just happened to finish first. The others will be along in due time.

In an increasingly suspicious and hostile international atmosphere, life in the future could well become intolerable. The interior cities of our country would be little safer than New York or San Francisco. Indeed, many cities in, say, Ohio or Illinois are actually closer to parts of Europe and Asia than are most of our cities on the Atlantic and Pacific Coasts.

An enemy country could have rockets carrying atomic weapons trained on Pittsburgh, on Detroit, on every vital center in America, awaiting only the pressure of a button to send them off. It would be like living with a gun pointed always at our head. Sooner or later some future Hitler or Peron would find an excuse to pull the fatal trigger.

Few problems in the world are more fundamentally important to every one of us than the problem of maintaining world peace. How this problem is to be solved will determine, directly or indirectly, the amount of taxes you pay, the business you can do, and your chance of dying in a future atomic war. The world, for the first time in history, has been reduced to manageable size; and that means that, sooner or later, by orderly process or by violence, someone will manage it—either a world dictator or a world democracy.

Now, it seems to me that just as air transportation has helped to *create* this problem, it can also help to solve it. World organization, if it is to be effective, must be preceded by world understanding. Otherwise, at the best it can only be a roof over chaos; and at the worst, tyranny.

An indispensable preliminary to the establishment of an international legal order is the development of what Walter Lippmann has called a "common law of the world." Just as a city police force works only because the citizens are in general agreement as to the laws to be enforced, so a law-abiding *world* community will work only when there is widespread understanding and agreement among the governed. This essential preliminary to the formation of a world state, to the maintenance of peace by law, has not been sufficiently emphasized, I believe, in such otherwise admirable books as Emery Reves' "The Anatomy of Peace," condensed in the January *Reader's Digest;* or Clarence Streit's "Union Now."

If people are to be prepared for world citizenship, they must visit the laboratory of the world in far greater numbers than ever before, and learn firsthand about other people's problems. This is air transport's great opportunity, as well as its responsibility, to help create the climate of peace.

INTERNATIONAL AIR TRAVEL CAN PUT A FLOOR UNDER PEACE

In a little book on *Civil Aviation and Peace*, which some of you may have seen, I have suggested, you may recall, that "a 3-cent fare to anywhere should be air transport's goal." At such a rate a flight from New York to London, for example, would cost about $100. Recent nation-wide surveys have shown that with rates at approximately this level, and *no place on earth over two days away*, an enormous overseas travel would develop. Such travel would foster trade, create jobs, and contribute to domestic prosperity in every participating country. From this new channel of commerce undreamed-of streams of development would flow.

Mass air travel overseas would help, for instance, to offset the dollar shortage abroad, so that foreigners could buy more of our goods and services. Dollars spent abroad in effect never leave home. To buy a meal or pay a hotel bill in Paris or Peru you need francs or pesos in normal times, not dollars. Dollars used to purchase local currency come back to us when foreign customers buy our industrial machines, our durable goods, or other products, or pay interest on the billions of dollars we are being asked to lend abroad.

A good way to make sure that debtor countries have dollars on hand to pay the interest on our loans when it falls due is to make it easy for you and me—and millions like us—to fly down to Rio, see the Acropolis, visit Victoria Falls, the Taj Mahal, Peiping, Bagdad, and all the other fascinating places of the world. Can you think of any pleasanter way to collect interest on a loan?

Mass air travel of this character would stimulate the development of backward areas. It would help to stabilize international economic relations and thus put a floor under peace. It would create a climate conducive to international understanding. In time it would transform the world.

Evidence that this principle is becoming increasingly understood may be seen in the declaration contained in the recent aviation agreement between the United Kingdom and the United States, signed in Bermuda in February of this year. The two governments state that their purpose is "to foster and encourage the widest possible distribution of the benefits of air travel for the general good of mankind at the cheapest rates consistent with sound economic principles; and to stimulate international air travel as a means of promoting friendly understanding and good will among peoples and insuring as well the many indirect benefits of this new form of transportation."

How soon we can hope to have an average fare of 3 cents a passenger-mile on a self-supporting basis is difficult to say. So many factors are involved. It depends in part, for example, on the economies which may prove to be possible with operations on such a mass scale; on technological improvements already on the way; on future intensive research; and, to an important extent, on federal policy.

That a 3-cent level of fares on a self-supporting basis can be reached in due time by progressive stages, appears incontestable. The question is whether, in the interest of advancing world understanding and trade, it may not be desirable to adopt a policy of federal aid which will hasten achieving a 3-cent-a-mile goal in the shortest possible time. The by-products of such a policy will contribute directly to national security, as they will help to assure a healthy aircraft-manufacturing industry, a reservoir of skilled aviation personnel, and a nation of air-minded citizens. Such temporary aid would also be a small premium to pay as insurance against future possible aggression.

WORLD UNDERSTANDING MUST PRECEDE WORLD ORGANIZATION

The disposal of surplus property abroad may seem a far cry from what we are discussing. Yet it offers, I believe, a promising way to stimulate international understanding. We own outside the borders of our country 5 to 10 billion dollars worth of surplus property, scattered throughout the world. Much of it will have to be sold or otherwise disposed of on the spot. A substantial part, perhaps several billion dollars worth, could be used locally for postwar civilian purposes by foreign governments and citizens. Yet they can purchase it only by using their own currency, since in general they are short of U. S. dollar exchange.

It would be entirely feasible for our Government to accept payment for this surplus property abroad in the local currency, to the extent necessary, and then to stimulate international travel by making the money available, at attractive tourist rates, to you and me when we go abroad. A similar plan for stimulating travel, you recall, was used by a number of countries before the war. If this idea appeals to you, please pass it along to your Congressman. The Treasury Department is struggling with the problem right now, of what to accept for money when offering for sale our surplus property abroad.

Another plan which might be given a trial, while waiting for air fares to reach the level of the average pocketbook, is a program of Air Travel Fellowships. Such a program should be directed particularly toward teachers, and others of relatively modest incomes, who are in a position to influence large numbers of people. Toward those who, as Dean Gildersleeve has said, bear the grave responsibility of seeing that "all our citizens, so far as their mental capacity permits, understand at least in broad outline the world situation, the immense importance of human relations and especially relations between nations, the great experiment of the United Nations, the character and ideals of our own country and its heavy responsibility of leadership in promoting the welfare of mankind."

Suppose committees of leading citizens were set up in each state to select a certain quota annually of Air Travel Fellows. This selection need not be limited to any one class. The Fellows might be teachers, clergy, editorial writers, engineers, or others. In selecting them the state fellowship committees would consider their ability to get the most from their travel experience, and their character and other qualifications which fit them to represent the United States at its best in their contacts abroad. The selection boards would also consider the opportunity of the applicant in his chosen profession to reach and influence others on his return home, in the interest of better international understanding. There should be open competition for such fellowships, preferably following enrollment in pretravel preparatory courses. Similarly, teachers in foreign lands would be chosen as Air Travel Fellows so that they might visit the United States and learn firsthand the American point of view.

Most of you, I am sure, would agree in theory that such a plan is a good idea, but I can imagine some of you saying, "What are you going to use for money?" Well, here is an idea which perhaps you can help persuade our air-lines is in their own interest to adopt: In normal times, you know, an air-line rarely operates with 100 per cent full loads. When a plane takes off, three or four seats out of every 10 still remain unsold on the average. This may be hard to believe right now with travel at its present peak; nevertheless it is a normal condition which every traffic man will understand. The number of unsold seats varies greatly, of course, from flight to flight and from season to season. In rush periods it will be less, and in slack hours or seasons, more. *On the average*, however, throughout the year, we can normally expect in a 50-passenger plane some 15 seats remaining unsold.

Now, suppose arrangements could be made for the winners of these Air Travel Fellowships to occupy at least a portion of the unsold accommodations, on a special "deferred passenger" basis. That is to say, they would travel on a space-available arrangement, with possibly 12 or 24-hour notice. If necessary, this travel could be limited to off-season or off-hour flights. The Fellows would pay a special Air Travel Fellowship deferred passage rate of, say, a penny a passenger-mile. On this basis they could cover 10,000 air-miles for a cost of $100. Yet they would not displace any revenue load carried at normal rates; and as generators of additional air-line traffic, they should be very effective.

A teacher from Chattanooga or Fort Wayne, or any other city in the country, winning an Air Travel Fellowship could fly to a number of foreign countries and spend six to eight weeks of purposeful study and travel abroad at a total cost, including both transportation and living expenses, of a few hundred dollars. What teacher worth his or her salt could not beg, borrow, or wangle a few hundred dollars for such a privilege?

The cumulative effect of, say, 5000 of these fellows returning each year to their classrooms, pulpits, or editorial desks would be tremendous. In a relatively few years they would reach and influence millions of youth and others in this country and abroad. In the aggregate, they would do much to weed out the intolerance, prejudice, and ignorance that constitute such an obstacle to world understanding today.

Many of us since V-J Day have been greatly disappointed with the way events have gone. We expected too much of victory. We forgot that all victory did was to remove certain specific dangers. It did not bring peace or anything like it.

Peace is more than the absence of fighting; it is a manner of living together. The waging of peace calls for a program of positive action. It will be the tragedy of our times if history records that the mantle of world leadership has fallen on us—the most powerful nation on earth—before we are ready, mentally and spiritually, to receive it. We need to remind ourselves of the words of that great American, Theodore Roosevelt:

"We have no choice, we people of the United States, as to whether or not we shall play a great part in the world. That has been determined for us by fate, by the march of events. We *have* to play that part. All we can decide is whether we shall play it *well*, or ill."

Future of Air Transport

IN his presidential address to the Institute of Transport, delivered in London, England, last year, Sir Frederick Handley Page said concerning "Transport by Air and Its Future:"

The war, with its prodigal expenditure of brain and man-hours on the improvement of the airplane and its power-plant as a fighting machine, has compressed perhaps thirty years of normal technical development into less than six years. Many of these new technical developments promise much for the future safety, economy, speed, and regularity of air transport. Jet or gas-turbine propulsion and its numerous derivatives, rocket power, radar and laminar flow, and low-drag aerofoils, are all capable of diversion to serve the needs of the transport operator and the user of high-speed travel the world over.

A little farther from practical achievement, but now no longer to be overlooked as a future engineering possibility, is the controlled use of the atomic power which, among its many other and incalculable consequences, would assuredly revolutionize the design of aircraft power-units and open up fresh scope for enhanced speeds and efficiency.

The word "speed" as applied to transport embraces more than the speed of the vehicle. It includes speed from the time when the intending passenger makes his decision to travel, thus calling for brief intervals between services in comparison with competing forms of transport. The air provides a new aspect of the advantage of the motorcar in your own garage and the train for which you may have some hours to wait. Hence, airline operators are attaching great value to frequency of service, which in turn, other factors being equal, favors the use of aircraft of the smallest size compatible with distance to be flown, technical requirements to attain the needed speed, comfort for the passenger, and facilities for the handling on board of passengers and freight.

How fast will the postwar airliner fly? Great expenditure of power and consequent great cost gives speeds in service aircraft rising above 500 mph. Economic speeds deserving consideration in commercial air transport are still far below that level. The fighter, with its 2500-hp engine and weight of horsepower ratio of about 4, can carry little more than fuel for an hour and its armament and pilot. The transport aircraft, loaded perhaps to 15 lb hp, can fly for several hours and carry a good payload as well as the necessary fuel, but its speed will inevitably be less.

Air transport is obviously more international in its scope than any other form of transport. The ship, the train, and the automobile can be stopped at frontiers or where water meets the land. The airplane scorns such barriers.

The entire text of the address appears in the November-December, 1945, issue of *The Journal of the Institute of Transport*.

MILLING-CUTTER DESIGN *for* CONTINUOUS PRODUCTION

By ARTHUR A. SCHWARTZ

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THE milling machine has been much further developed than its milling cutters. Reviewing the conditions existing today, it can be said that the carbon-steel milling cutter is ancient in design but still the best for use on the softer metals, such as aluminum, brass, and magnesium, as to speed of chip removal, tool life, and finish.

Besides the carbon-steel cutter, the most common cutter is of the high-speed-steel type. In looking over some of these cutters, one that has never been used can be found lying next to its duplicate, apparently of the same size. Using a micrometer, and measuring the outside diameter of each, the chances are eighty out of a hundred that they will vary by several thousandths. If a pair of slotting cutters were put to work there would be only a slight chance of obtaining two slots having the same dimensions.

Looking at another pile of cutters, it will be found that some are sharp, some are dull, some have been through a salvage operation. They all fit in the same category: Not good enough to keep and too good to be thrown away.

About five years ago a drive was started to eliminate excess teeth in milling cutters and substitute cast- or soft-steel bodies with brazed-on teeth of any preferable cutting material. The slogan those days was: A healthy bite for every milling-cutter tooth. The number of teeth was limited by the amount of material that could comfortably be handled by the motors and spindles of the machines without overloading and still make the feed such that each tooth would get a healthy bite. This was confirmed by tests made by O. W. Boston at the University of Michigan which proved that the tooth that took a bite of from 0.002 to 0.010 in. performed better and had double the tool life of the tooth that just skidded and slipped over the work.

Since then many such cutters have been made, advertised, and sold and many a foreman and old employee has been converted. That is why a few cutters of this type are found hanging in the tool crib. Most of them are out on the job or are in the grinding crib awaiting their turn to be sharpened.

One more type of cutter that should be mentioned is the inserted-tooth cutter. Every one of these is the best that can be made of this type of cutter, particularly as regards the way the blades are inserted and held—so say the manufacturers of the cutters. The manufacturers may be correct, but this author has yet to see the perfect lock for an inserted blade. Most of these cutters are fine tools and they are a step ahead of the old, solid, one-piece cutters that wasted so much good cutting material. They also have excess teeth; but instead of knocking them out—just omit putting them in.

In the grinding crib one or two operators may be seen grinding drills, others are grinding lathe tools, and the expert is grinding broaches or form tools; but most of the operators are grinding milling cutters. Why is so much time spent on milling cutters? Are the mills the predominating machines in the shop? Far from it. It is because of the long time necessary to grind a cutter and the short life of the tool between grinds.

When a milling cutter dulls, a freshly ground one replaces it. But the freshly ground cutter does not have the same dimensions as the dulled one. Furthermore, it will not seat on the arbor as the other one did. When a reground or new cutter is put to work the machine must be ready to turn out the same work that it did with the previous cutter. From year to year working tolerances are becoming closer. More accuracy is being called for, and it is a time-consuming job to set up a milling machine to hold close tolerances. Hence to set up a cutter in a milling machine takes time.

This is the picture of present-day milling. The facts presented can be easily checked by anyone. However, another category of cutters should be added to those already in the crib, one that will help make the milling machine a true production tool by reducing the time required to set up, and the time required to sharpen the cutters.

To achieve this much desired result three provisions are necessary:

(1) A newer, quicker, and simpler way to sharpen the cutters in order to eliminate at least 80 per cent of the time now required.

(2) A simple system of blade insertion and locking that will make it possible for the new blade to seat exactly as every other blade of the series would seat and eliminate 95 per cent of the setup time now required to change cutters.

(3) A way to make precision grinding of the blades and the production of the blades rapid, simple, and easy.

Undoubtedly these results can be achieved in many ways. It is hoped that interest will be aroused so that some of the shops will try to achieve them.

At Bell Aircraft Corporation a system has been developed which is thought to be good. Experiments and tests have proved that it works. It was found that the three provisions just mentioned were absolute "musts."

A separate grinding fixture, Fig. 1, is provided with as many blade slots as possible. All the slots are alike in dimensions, angle, and radial distance from the center. Another fixture is provided, Fig. 2, for holding and spinning the grinding fixture. This is the grinding setup. The blades are given a circular, rough, and finish grind. Shapes and contours may be determined by a template attached to the fixture, which operates against a nib, representing the grinding wheel which is fastened to the table of the grinding machine, as shown in Fig. 3. A better way is to use a drawing or photograph of the contour in a special comparator attached to the grinding fixture.

Always the first step in cutter grinding and familiar to all grinders, this one operation completes not only one cutter but two or more, depending on the number of blades used in the cutter and the number held at one time by the grinding fixture. Suppose the cutter used four blades and the grinding fixture held sixteen. It would mean the complete grinding of

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Contributed by the Production Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

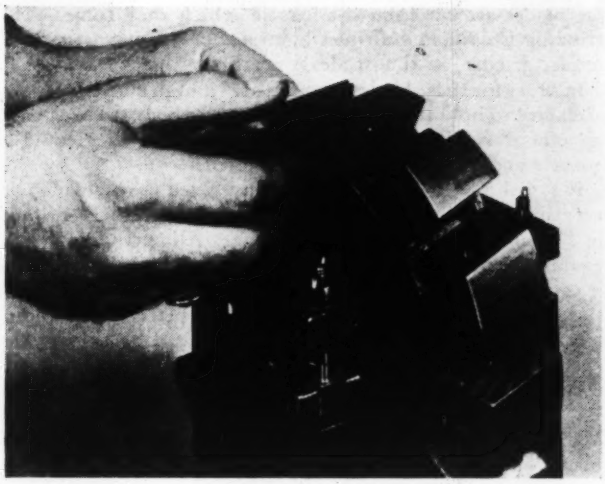


FIG. 1 GRINDING FIXTURE SHOWING THE SLOTS FOR RECEIVING BLADES

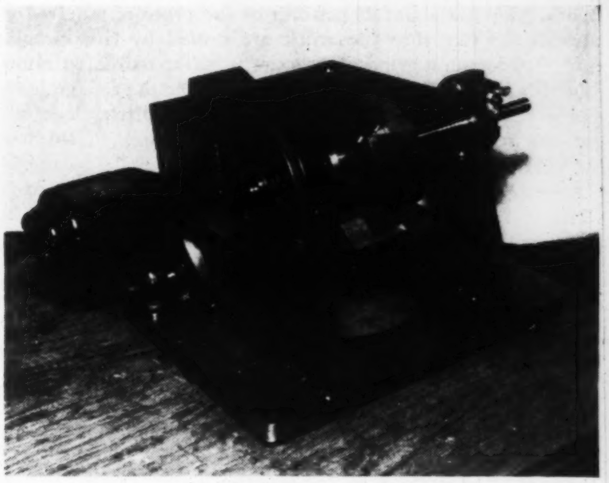


FIG. 2 FIXTURE FOR HOLDING AND SPINNING THE GRINDING FIXTURE

four cutters during the time now spent in circular-grinding one cutter. The estimate of 80 per cent saving in grinding time is conservative indeed.

All four slots of the cutter body also must be alike in dimension, angle, and radial distance, and there must be a 5-deg angular difference between the slots in the cutter and the grinder, both radially and axially, so the blades sit up 5 deg straighter in the cutter. (See Fig. 4.) This change of position gives the clearance. University of Michigan tests indicate 6 deg to 7 deg as the best clearance, but that was grinding in the old way which was a series of reverse curves. Here attention should be called to the "land" that is left on most cutting tools that travel or cut in a circle. This land, which is really part of the original circular grinding, no matter how narrow, still prevents the tool from advancing in the work. It slides under heavy pressure and generates heat where heat can do the most damage—at the cutting lip of the tool. In milling cutters and similar cutters more than 25 per cent of the detri-

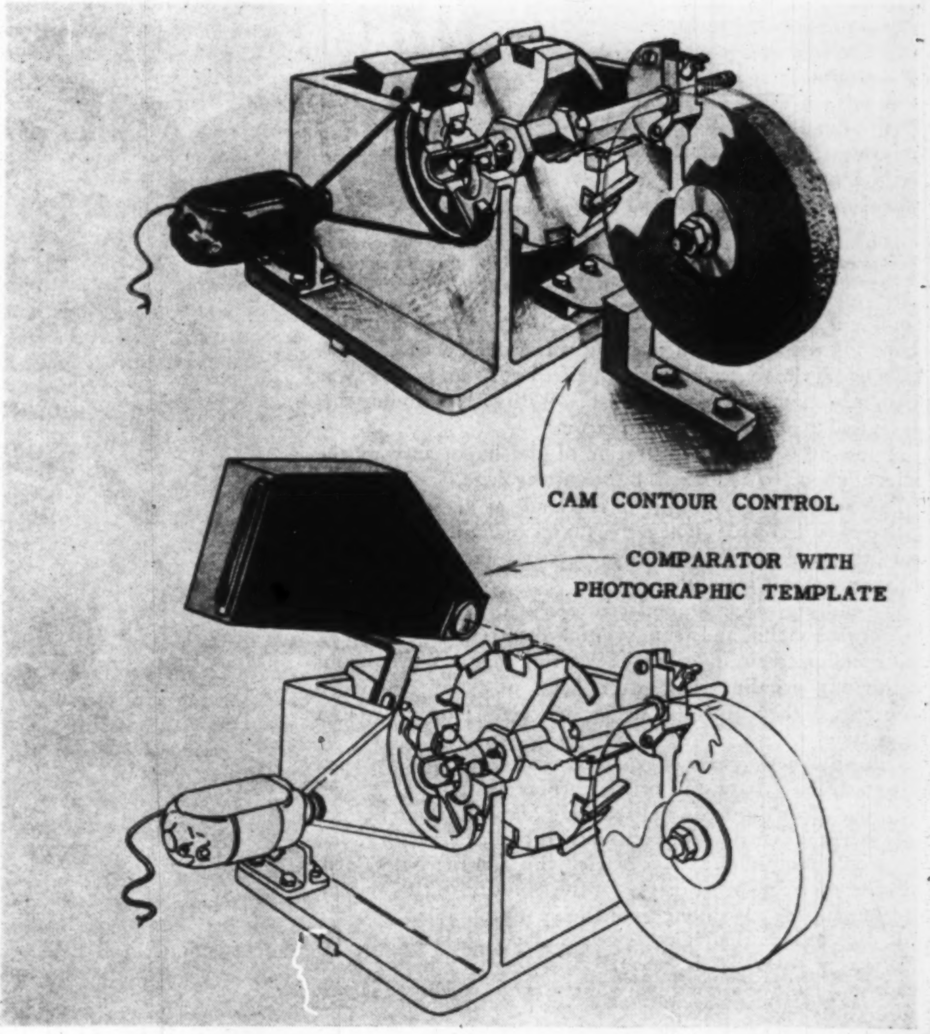


FIG. 3 CONTOUR GRINDING CONTROLS

mental heat and about 25 per cent of the pressure required to advance the tool into the work are caused by this circular land. In common grinding practice it is impossible to eliminate this land without spoiling the contour. Years ago lands had to be stoned by hand in order to create a little clearance; but the stoning had to be done by experienced machinists, the kind that are scarce today.

Recently a special router bit was made which had to be hand-held and operated. A 2-hp 21,500-rpm motor weighing about 5 lb was used. When the bit was ground with a land as made by all the router-bit makers, a feed of 20-in. per min was about maximum for an average man. With careful stoning this was raised to better than 60 in. per min.

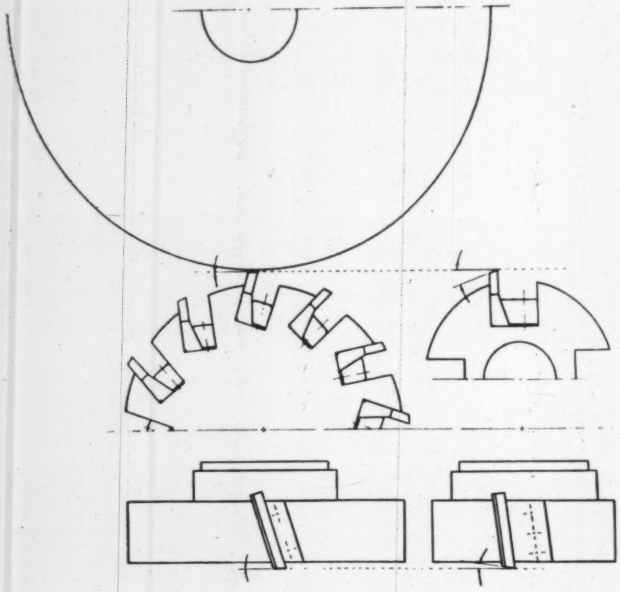


FIG. 4 HOW CLEARANCE ANGLES ARE OBTAINED

(A slab and side mill combined is shown from which it can be seen that either type of cutter can readily be made by this system.)

Following is a good illustration of the importance of the relief angle up to and meeting the cutting edge.

This system of grinding with the blade at an increased (if positive) or decreased (if negative) axial and radial angle automatically produced the ideal edge clearance—actual relief with the maximum lip strength.

The milling research conducted recently in Michigan and California has time and again mentioned cutting-edge chipping and grinding cracks in or near the cutting edge. With present methods of grinding these are difficult to avoid, and when they appear they generally render the cutter inoperative in a short time.

Using this new system of grinding, cracks are easily avoided. Even extremely hard and brittle carbide can now be ground with due care as to feeds and sparking out; and the relief not only meets the cutting edge without chipping or cracking, but a smooth shiny surface that extends the tool life is obtained.

If there were no other reason for the adoption of this system, this fine cutting edge alone would make it profitable.

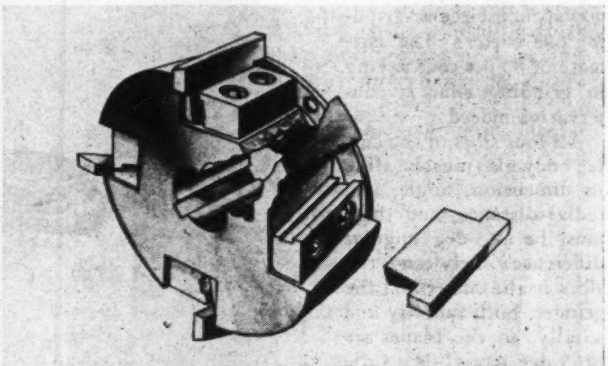
It may be said that it takes two surfaces to make an edge and that is true. With the present system of grinding, each blade face must be ground individually when it is in an almost inaccessible place.

This face of the blades should be ground and polished before the blades are cut from the bars in which they come. This grinding is done in multiples by means of the magnetic-chuck surface grinder, an almost ideal operation.

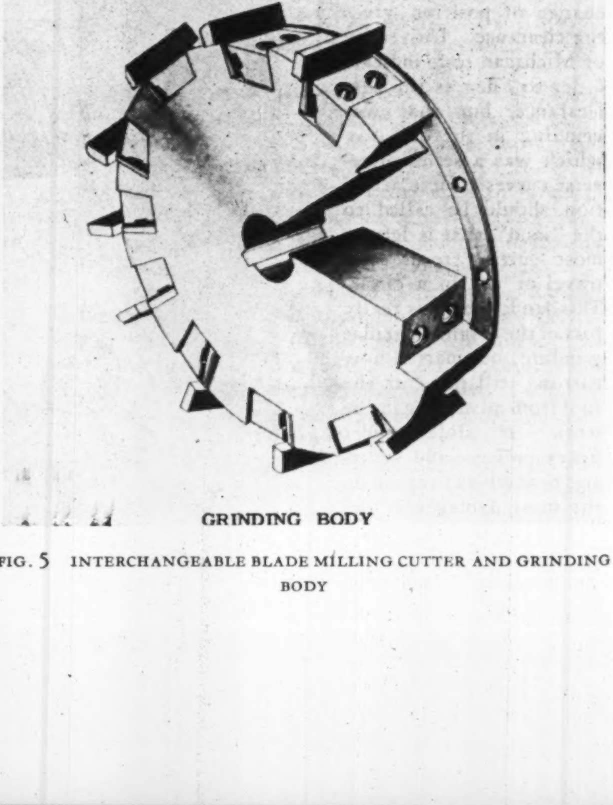
In order for these blades to operate at a high efficiency it was necessary to hold them solidly in the cutter body, to back them up against breakage, and to arrange it so that they could be quickly and easily extracted and inserted.

Fig. 5 shows how this problem was solved. The blade is of very simple construction—a wedge-shaped piece of metal held in a plain slot by an opposing wedge. All cutting forces act against two smooth planes at right angles to each other, and it is not necessary to remove the wedge block as the blade will slide out freely and the new one takes its place. This sliding motion helps to prevent misalignment caused by chips. Free egress is left for chips and either a little air or coolant will clean out the slot to assure proper alignment of the sharp blade in "identical" position with the dull one. The word "identical" is emphasized as much as possible in that the size of the blade need not be known since that is taken care of by the first setup of the mill. All that need be known is that the new blade have the identical measurements of the dull blade.

To make things identical with this system it is required to cut only the slots in cutter and grinding body each at one setting of the milling machine, and to grind all the blades either to template, or comparator, or both.



MILLING CUTTER



GRINDING BODY

FIG. 5 INTERCHANGEABLE BLADE MILLING CUTTER AND GRINDING BODY

An Introduction to ROCKETS *and* JET PROPULSION

By G. EDWARD PENDRAY

SECRETARY, THE AMERICAN ROCKET SOCIETY AND INDUSTRIAL PUBLIC RELATIONS COUNSELLOR

JET propulsion is a method of developing thrust or push by ejecting a stream or jet of gas or other matter at high velocity. It will thus be seen that jet propulsion is the name of a general principle of propulsion, which may be applied to the driving of any suitable vehicle. We might imagine almost an infinite variety of such vehicles, moving through air, water, or space. The squid, for example, is an underwater vehicle driven by jet propulsion. Being a kind of fish which long antedated man on this globe, the squid, can therefore probably establish a satisfactory claim to the invention of jet propulsion, having been using it successfully now for more than 10,000,000 years.

In the matter of air and space vehicles, we can discern two broad types which are usually known as jet planes and rockets. This brings us to two more definitions which, while simple and obvious, may nevertheless help to further clarify some of the word-produced confusion on this subject. A jet plane is an "aircraft," either with or without pilot, which is driven by jet propulsion. A rocket is a "projectile" driven by jet propulsion. Thus, we may see that a jet plane, like an ordinary aircraft, depends for support in flight on the interaction of the air and its wings. It cannot fly except through air, and depends on that air for its support.

A rocket, on the other hand, is a projectile, and thus is not in any way dependent on the air for support; in fact the air impedes it. It is supported in flight entirely by its kinetic energy or momentum, and follows a trajectory which in no way is dependent on the air, though of course it may be altered or shortened by the resistance of the atmosphere.

The jet plane and the rocket are therefore two quite different kinds of vehicles with one thing in common, both are driven by jet propulsion. The kinds of motors or engines that drive them may be, and in some cases are, identical; though in actual practice it is customary to use a continuous-power engine of the air-jet variety to drive aircraft, and a high-power rocket motor to drive a rocket.

THE ROCKET MOTOR

Let us consider the internal construction and the operation of the simplest and best known of all the jet-propelled devices, i.e., the ordinary skyrocket, Fig. 1. At the top will be noted a cone-shaped hat, filled with black pellets. These are the "pay load" of the skyrocket, for they are the fiery stars which the rocket will eject at the top of its flight, to give the familiar pyrotechnic effect.

The stars, of course, have nothing to do with propelling the rocket. This is accomplished by the material in the cylindrical portion of the rocket just below. The outer case is usually made by soaking pasteboard in glue and water, then rolling it on a mandrel to give it the cylindrical form. Before the material hardens, the lower part is drawn in to provide a crude nozzle.

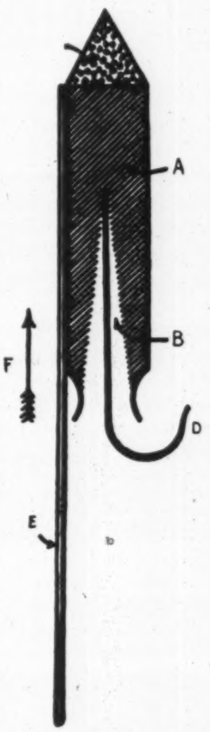


FIG. 1 CROSS SECTION OF A SKYROCKET

Now, when the rocket is charged (which must be done, of course, before the "star" compartment is put on) a cone-shaped dibble is driven up through the nozzle, and black gunpowder or a similar propellant mixture is packed in all around it, driven hard with the aid of a mallet or hydraulic press. When the dibble is withdrawn, a cone-shaped cavity remains in the lower part of the charge, a cavity which is sometimes picturesquely referred to as the "soul" of the rocket. The fuse, leading in from the outside, ends in this cavity.

When a skyrocket is fired, the sequence of events is as follows: The spark follows the fuse into the cavity, and ignites the walls of the powder charge. Though the charge usually consists of gunpowder, an explosion does not occur because the charge is so tightly packed the flame cannot permeate it, and can only burn therefore on the walls of the cavity. As it burns the cavity enlarges rapidly, and the fuel is transformed into gas at high temperature and pressure. There is only one place it can escape, and consequently a jet goes roaring out of the nozzle, thrusting the rocket in the opposite direction.

Now this thrust is not produced, as is very commonly but erroneously supposed, by pressure of the jet against the air. Instead, it is produced by a state of unbalanced pressures in the rocket, whereby there is more gas pressure on the forward part of the combustion cavity than at the rear. The thrust is further enhanced by the action of the nozzle, which increases the velocity of ejection, facilitates escape of the gases, and directs the flow.

We can more readily see how a reaction motor works by imagining a closed box containing gas under pressure. In such a box, according to the laws of gases, the pressure on every square inch of each side will be exactly counterbalanced by the pressure on the opposite side. Consequently, there will be no tendency to motion. But now, suppose a hole is made in one side. The gas that would have pressed upon that area now escapes, and there is no longer a condition of balance in the box. There will be a tendency to move in the direction opposite the hole, and the push will be roughly proportional to the product of the gas pressure and the area of the hole. In such a box the action would not long continue, of course, because the pressure would rapidly fall. But if new gas is brought in, or fuel burned to keep up the pressure, the action will continue.

This is exactly what happens in a skyrocket. In such a

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rocket, we see all of the parts essential to a reaction motor. These parts are three in number: namely, (1) a combustion chamber or gas chamber where there is gas under pressure, (2) a hole or orifice through which some gas can escape in a directed stream, and (3) a nozzle which facilitates the escape of the gas at high velocity.

The skyrocket motor is technically a "dry-fuel rocket motor." It is one of the five basic types of motors and engines now developed which work on the broad principle of jet propulsion. This dry-fuel motor is simple and ingenious. It contains no moving parts; it combines in one unit the fuel supply and the engine. It is completely independent of the air, since it needs no external oxygen for the combustion of its fuel, and like all jet-propulsion engines and motors, it needs no air to push against.

The dry-fuel rocket motor, in somewhat differing arrangement and of course using more powerful propellants, such as cordite, is the type that drives the bazooka rocket, the antiaircraft rocket, the airplane rocket, the rockets used in amphibious landings, and the like. In fact, virtually all relatively short-range military rockets employ the dry-fuel motor because of its simplicity, compactness, and freedom from the need for field adjustment or charging.

It has, however, two major disadvantages: Once it is ignited the rate of combustion cannot readily be controlled or modulated from the outside. A still more serious difficulty is that there are no dry or solid fuels which provide enough propulsive power for really long-range rocket trajectories.

For a way around both these difficulties, we must go to the liquid-fuel rocket motor, or as it is more technically called, the liquid-propellant rocket motor. In Fig. 2 we have the schematic outline of both kinds of rocket motors. The dry-fuel (or solid-propellant) motor is at the left. The scheme of the liquid-propellant rocket motor is shown at the right. In this design, the propellants are brought in through mixers or inlet ports at the upper part of the combustion chamber and are reacted together in the chamber. The resultant gases jet through the nozzle, providing thrust.

It will be noted at once that the liquid-fuel motor, unlike its dry-fuel counterpart, requires the use of separate tanks or containers for the propellants. As a result, the motor considered by itself can be surprisingly small and light. A motor capable of producing 100 lb of thrust can be held in the palm of the hand. The German V2 rockets made use of a liquid-fuel motor producing 60,000 lb of thrust (30 tons), and this entire thrust was produced by a motor a little more than 6 ft long and weighing about 1000 lb.

It should be noted, also, that at the most favorable portion of the V2 flight, this relatively small motor produced power at the rate of well over 600,000 hp. The liquid-fuel rocket motor may well be, for its size and weight, the most effective device available to man for the conversion of chemical energy into mechanical power. The fuels available for such motors yield several times as much energy, pound for pound, as gunpowder. The Btu content of black powder is about 1000 per lb, and that of smokeless powder, 1870. Gasoline and liquid oxygen, a common liquid-fuel-motor combination, provides some 4220 Btu per lb, more than 4 times that of black powder. And liquid oxygen and hydrogen, a theoretically possible fuel combination, though admittedly a nuisance to handle, will yield 5760 Btu per lb.

Like the dry-fuel motor, the liquid-fuel rocket motor needs no air to push against, and no air to supply either of the components of its combustion. It is, accordingly, completely independent of the atmosphere, and is the motor which rocket engineers expect will drive the long-distance military rockets of the future, the possible mail and express rockets, and even the passenger-carrying long-range rockets, if there are to be any.

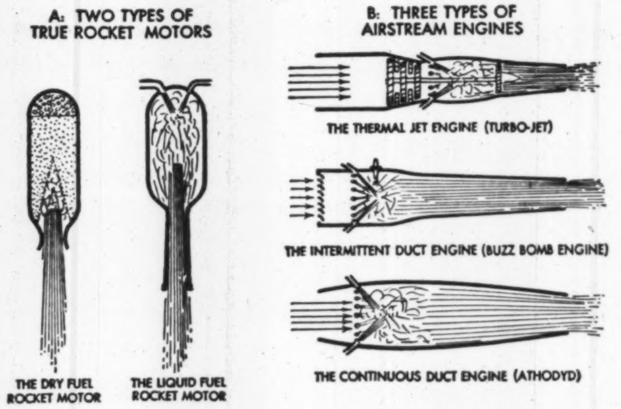
A: TWO TYPES OF TRUE ROCKET MOTORS
B: THREE TYPES OF AIRSTREAM ENGINES
THE THERMAL JET ENGINE (TURBO-JET)
THE INTERMITTENT DUCT ENGINE (BUZZ BOMB ENGINE)
THE CONTINUOUS DUCT ENGINE (ATHODYD)
THE DRY FUEL ROCKET MOTOR
THE LIQUID FUEL ROCKET MOTOR

FIG. 2 SCHEMATIC REPRESENTATION OF THE FIVE TYPES OF REACTION MOTORS

AIR-STREAM ENGINES

The rocket motors, because of their simplicity and the furious rate at which they liberate energy, are best suited to the propulsion of rockets, that is to say, projectiles. But there can obviously be another class of jet-propulsion devices, usually called the "air-stream" or "air-jet" engines, which are better for the propulsion of aircraft, because they can exert steady power over long periods of time, and draw one of the components of their propellants, the oxidizer, from the atmosphere itself.

Such engines, unlike the true rocket motors, will be dependent upon the air. They will need no air to push against, of course, but they nevertheless must obtain from the atmosphere the oxygen needed to consume their fuel, and likewise must draw on the atmosphere for a large mass of inert material which can be ejected to provide high thrust at relatively low speeds; low speeds, that is, for reaction motors.

Perhaps this latter point needs to be clarified. The thrust of a reaction motor of course is exactly equal to the mass of the jet multiplied by the velocity of ejection. It is obvious therefore that thrust can be increased either by increasing the velocity of ejection, where the mass must be held to some definite limit, or by increasing the mass, where the velocity must be limited. Because the craft itself moves rather slowly, the engine intended to drive an airplane should have a relatively slow jet, and must therefore eject a relatively large mass. This large mass, together with the oxygen needed for combustion, the air-stream engine can get for the taking out of the air through which it flies. Fig. 2 shows schematic diagrams of three principal types of air-stream engines.

The one at the top, Fig. 2 (*B*), which is the best known, is technically referred to as the "thermal-jet" engine, or more familiarly as the "turbojet." Air enters this engine through a collecting collar at the left, is compressed by means of a rotary air compressor into a combustion chamber, where fuel is injected into it and burned. The resulting gases and the large volume of heated unburned air then pass rapidly out through the nozzle at the right. On the way they are forced to pass through the blades of a gas turbine, which extracts some of the power to operate the rotary air compressor. It will be seen that in this type of device, some of the energy of the jet, as a matter of fact about two thirds of it, is used to keep the cycle going, and only the remainder is available to provide thrust.

Nevertheless, this is a very good engine, and was the type used in England to power the Gloster Meteor which recently set a speed record of more than 600 mph. It is also the type of engine used in this country to power the Bell Airacomets and the fast-flying P-80 Lockheed Shooting Stars. Toward the end of the war, the Germans had at least two jet-driven aircraft, powered by turbojet engines, which were capable of speeds up to about 600 mph. They were in production on these engines at the rate of more than 1000 per month.

The second type of air-stream engine is that in the middle, Fig. 2(*B*), which is referred to by the British as an "intermittent-duct" engine, and by American engineers as a "resojet" or a "pulsojet." It is also sometimes called a "buzzbomb" engine, because it was this kind of device that drove the German VI weapons, or buzzbombs.

In this engine, the action must be started either by compressed air or by rapid forward motion, such as the Germans give it with their buzzbomb launching ramps. When the head pressure reaches a suitable level, the spring-controlled flap valves at the forward end of the tube are blown open, and the air enters the combustion chamber, where it is mixed with gasoline and fired. The resulting blast blows the shutters closed. Expansion then forces the gases of combustion and the column of air out the rear, producing a jet. But this leaves an area of low pressure in the chamber, which automatically opens the shutters again. More air comes in, and the cycle repeated.

The rate of the cycle depends upon the resonance and hence, upon the length of the tube. In the German buzzbomb engine, the tube was about 11 ft long, and the rate of firing about 40 times per sec. It is because of this resonance effect that this device has been called the resojet or pulsojet.

The buzzbomb engine, at the present state of its development at least, isn't much of an engine in so far as efficiency goes. But it is so light and simple, and so cheap to produce, it may nevertheless have many uses both in war and in peace. It was, of course, well suited to driving the German buzzbomb. The power plant of the buzzbomb represented only 8 per cent of the total starting weight of the craft, and permitted a pay load that represented nearly one half the launching weight.

The third air-stream engine is sometimes referred to as the "continuous-duct" engine, though it is now becoming more familiar under the British name "athodyd" and the American appellation "ramjet." Athodyd, incidentally, is a classical-sounding title which has been made from significant letters of the original British descriptive name, the "aero-thermo-dynamic-duct." Ramjet fits the engine better than any of the other names and is finding increasing favor.

When the ramjet is moving forward (toward left in illustration) at the speed of sound or thereabouts, the air rammed into the open forward end expands in the combustion chamber and is there burned with gasoline or other fuel, to produce an accelerated movement toward the rear and out the nozzle.

Like the rocket motors, the ramjet needs no moving parts whatever for its operation, but it has the peculiarity that it will provide relatively little power until it gets going at speeds near that of sound. Consequently, unlike the turbojet, it can hardly serve as a source of primary power for aircraft, though it may well be most useful as a booster engine for high-altitude fast-flying jet-propelled aircraft using turbojets as primary power.

EFFICIENCY OF JET-PROPULSION MOTORS AND ENGINES

The efficiency of jet-propulsion motors and engines has been the subject of much discussion, and a good deal of the data that have appeared in print have indicated a low efficiency for jet propulsion, as compared with conventional engines, especially those used in driving the familiar types of aircraft.

While there is no quarreling with these figures, they often present a somewhat distorted view, arising from the fact that in a real sense jet propulsion and reciprocating engines are not competitors. There is a basic relation between speed and efficiency in all types of jet-driven craft, whether aircraft or rockets. This relation shows that mechanical efficiency, that is, the efficiency of conversion of the jet into forward motion of the driven craft, depends on speed and reaches its maximum value only when the craft is moving at the speed of the jet.

Now, the jet speeds of thermal-jet engines are of the order of 1500 mph and the jet speeds of the best liquid-fuel rocket motors are around 3500 to 4000 mph. It is therefore not surprising to find that jet-driven planes are large fuel consumers when they move along at only 300 to 400 mph. At the speeds which their engines perform best, but to which as yet no aircraft has been designed to fly, namely, at speeds from, say, 1000 mph and upward, jet-driven aircraft will be appreciably more efficient than reciprocating engines or any engines that make use of the propeller.

This discloses, incidentally, why jet propulsion is just now so interesting. What jet propulsion offers us is a new "dimension" in velocities, altitudes, and horsepower available for flight through air or space. Jet engines for aircraft begin to be effective only at the point where propeller-driven aircraft must leave off, i.e., at speeds above 450 mph, at altitudes greater than 6 to 8 miles, and at power output per engine from 3000 hp up.

The maximum horsepower that can be produced by jet engines is not yet known, but undoubtedly exceeds the maximum practical horsepower of any reciprocating aircraft engine of today. It has been calculated that jet engines for aircraft use can probably be built with thrusts as high as 15,000 lb per engine. Since at speeds of the order of 375 mph, 1 lb of thrust is equivalent to 1 hp, this means that single engines can possibly be built which will deliver, under suitable operating conditions, as high as 15,000 hp or more. The altitudes that can be reached with the aid of jet engines are, at least theoretically, greater than those reachable with the ordinary reciprocating engines. It seems probable that jet engines of various types ultimately will be able to fly at altitudes of 10 or even 12 miles, because the forward thrust of the engine itself serves to help gather and compress the air required to support combustion of the fuel.

As to jet-engine speeds; here again we do not know the practical limits, but it seems not unlikely that velocities up to 1500 or 2000 mph will be possible in so far as the engine is concerned. It will necessitate important changes in the design of aircraft to fly at such speeds, of course, and it is in the design of the aircraft that the lag now exists. Engines which have so far been developed, apparently would be capable of much higher speeds than any present aircraft can fly. Speeds of even 1500 or 2000 mph do not by any means represent the maximum that can be reached with the aid of jet-propulsion motors and engines. When we turn to true rocket motors, velocities measured in miles per second are certainly obtainable.

The best liquid-fuel rocket motors at present developed have jet velocities of between 6000 and 7000 fps. Since it is quite possible to build rockets which will reach the speed of the jet of their own motors, this means that we can think in terms of velocities during some portion of the trajectory of such a rocket which will exceed 1 mile per sec, or 3600 mph.

Such speeds are practical, of course, for projectiles; whereas they would probably not be practical for aircraft. We can expect that ultimately various types of jet-driven flying and trajectory craft will be developed covering an entire spectrum of flight velocities, ranging from 500 mph or so for relatively slow aircraft, up to rockets which will travel 4000 or 5000 mph. Speeds even greater than this may be reached. Velocities of the order of 22,000 fps or more than 14,000 mph, will have to be attained to shoot a rocket across the Atlantic Ocean. At these enormous velocities, which are theoretically possible, a rocket would traverse the whole distance from London to New York in a little over 14 min trajectory time. Equipped with wings to increase the distance and to provide control for landing, such rockets may require a little longer for the journey, maybe as much as $^3/_4$ hr.

THE FLIGHT OF ROCKETS

In so far as space and weight are concerned, the motor is a very small part of the total liquid-fuel rocket. Fig. 3 shows the schematic design of a sounding rocket, intended for vertical flight, carrying instruments. This prewar design is somewhat out of date now, but will serve nevertheless to show the principal parts of such a rocket, which do not vary appreciably from the long-range trajectory rockets such as the V2, except in size. This rocket was intended to land by parachute, and hence we have a parachute compartment at the forward end, where the warhead was carried in the V2. Just behind this is the pay-load compartment, where instruments would be carried in a sounding rocket, and where the Germans placed the control instruments used in guiding their V2. What follows, taking up more than two thirds of the length of the rocket, is the space occupied by the propellant tanks. In this small rocket the fuels were supposed to be forced into the motor by means of gas pressure; more particularly, by the pressure of oxygen vapor produced by evaporating some of the liquid oxygen. In the V2, as perhaps will be the case in all such large rockets, the fuels were forced into the motor with the aid of pumps.

In this sounding rocket, which incidentally was designed by James Wyld, past-president of the American Rocket Society, the control gyro, required to assure vertical flight, was placed just behind the fuel tanks. The motor, as in the V2, was located at the rear.

This design illustrates clearly the essential simplicity of a liquid-fuel rocket, and also makes clear that a major part of the space and starting weight of any long-range rocket, whether intended for vertical or trajectory flight, must be given to fuel. As a matter of fact, the fuel-weight ratio is of extreme importance. For major distance it must be such that the total weight of the fuels at starting amounts to at least two thirds of the starting mass.

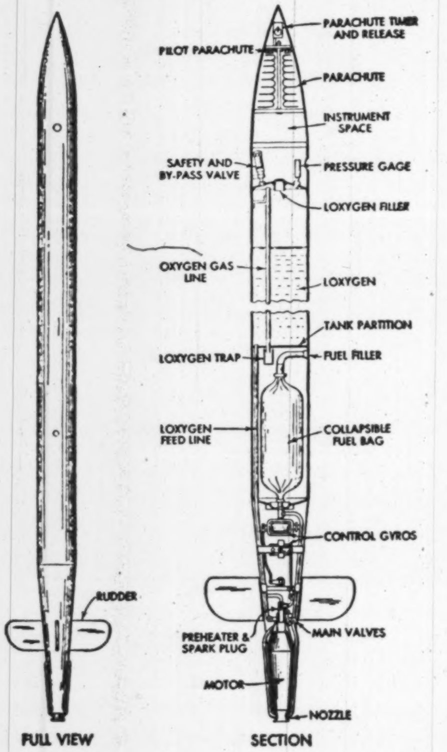

FIG. 3 ONE VERSION OF A SOUNDING ROCKET, WITH GYRO-CONTROL, REGENERATIVE MOTOR AND COLLAPSIBLE FUEL BAG

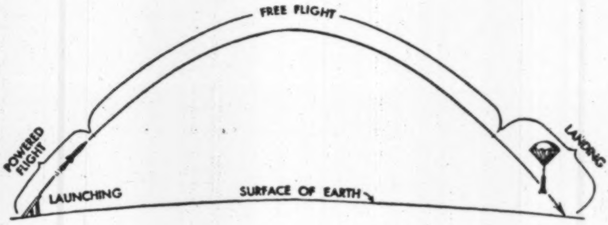

FIG. 4 ROCKET TRAJECTORY, SHOWING THE FOUR PARTS

It follows, from the nature of trajectory flight, that all of this fuel must be burned rapidly to transform in the shortest practical time the chemical energy of the fuel into kinetic energy of the rocket. The limiting factor on the rate at which the fuel can be burned is the resistance of the air. The rate of acceleration of the rocket must be so regulated that the rocket will not reach too great a velocity too low in the atmosphere, or else head resistance will rob it of too much power.

Calculation of the rate of combustion therefore is a complicated matter. At the risk of making it too simple, it can be said that the average rate of acceleration for a long-range liquid fuel will be of the order of 3 times gravity. The German V2 started with an acceleration of about $2^1/_2$ g and ended its powered flight with an acceleration of about 5 g.

The trajectory of a typical long-range rocket has four main parts, Fig. 4: First comes the launching, which is relatively brief and may consist, as in the case of the V2, of nothing but a short vertical flight to clear the ground before the trajectory control instruments were ready to take over.

There is next the highly important period of powered flight, during which the entire fuel supply is burned to give the rocket momentum. In most rockets this is a relatively short period. In the case of the bazooka, it is less than 0.1 sec. In the German V2 it was between 60 and 70 sec, during which time the motor burned about 10 tons of propellants.

By far the longest part of a rocket's flight is the free flight, which begins the moment the fuel is shut off or consumed, and lasts until the landing gear, if any, takes over for the final phase of the shot. Returning to our example, the V2 had a free flight of about 4 min, during which time it passed over from Holland to London, a distance of about 200 miles. At the highest part of the flight the V2 was about 60 miles above ground.

In order to permit this rocket to travel such a distance in free flight, the V2 motor had to give it a velocity at the end of powered flight of better than 5000 fps (about 3500 mph) and the control gyros had to so manage the flight that the angle of the rocket's motion relative to the earth at the end of powered flight was almost exactly 45 deg.

CONCLUSION

Though more than 700 years have elapsed since the invention of the first jet-powered projectile by the Chinese, the field of rockets and jet propulsion is still so new that in almost every direction the engineer encounters unknown factors. In matters of temperature, power, velocity, and control, jet engineers are working on the frontiers of knowledge and experience; yet much progress is being made, and the next few years will undoubtedly see spectacular development.

A LIQUID-PROPELLANT ROCKET MOTOR

By LOVELL LAWRENCE, JR.

PRESIDENT, REACTION MOTORS, INC., POMPTON PLAINS, N. J.

THE regenerative liquid-propellant rocket motor is the type that powered the German V2 robot bomb at the close of the recent war. This type rocket motor develops forward thrust by the rearward expulsion of combustion products at supersonic velocity. The rocket motor, as distinguished from current aircraft power plants of the jet-propulsion or propeller type, does not operate on atmospheric oxygen, but depends upon a supply carried with the motor. The oxygen is furnished by an oxygen-yielding compound, known as the oxidizer; the fuel may be any hydrocarbon, both of these being known as the propellants.

The jet-reaction engine under consideration utilizes liquids for propellants which are fed into the combustion chamber, and for this reason its operation cannot be compared to the powder or solid-propellant rocket motor whose entire charge of fuel is lodged in the combustion chamber. The liquid-propellant motor has been widely developed in both the United States and Germany because it can be repeatedly operated for long periods of time by merely replenishing the propellant supply.

CONSTRUCTION OF MOTOR

Basically, this rocket motor, Fig. 1, consists of an injector, the counterpart of the reciprocating-engine carburetor, a combustion chamber, nozzle, and cooling jacket. The injector indicated at 1 is made up of two chambers, one to feed the oxidizer into the injector jet, the other to feed the fuel. An igniter or starter, not shown here, is usually incorporated in the injector when the propellants used are not spontaneously combustible. The combustion chamber and exit nozzle are usually considered as a unit, as shown at 2, since the entire combination must be cooled with one of the propellants flowing in the space formed by the outer jacket and baffle, 3. It should be noted that since this cooling arrangement returns the dissipated heat energy to the combustion chamber with the propellant, there are practically no cooling heat-rejection losses, thus affording a regenerative power plant.

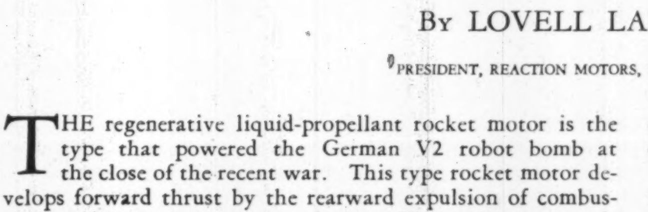

FIG. 1 BASIC SCHEME OF ROCKET MOTOR

After the propellant has traveled up the cooling jacket, it then enters the space at the entrance to the injector jet, and finally enters the combustion chamber, impinging on the other propellant which has entered at 4. It is possible to use as a coolant either the oxidizer or the fuel, depending upon their characteristics.

In the combustion chamber the fuel and oxidizer are burned, thereby converting thermal energy into high-pressure gases which are ejected from the exit nozzle. The exit nozzle changes the internal energy of the rapidly expanding combustion gases into kinetic thrust energy by accelerating the gases to supersonic velocities as they move from the high-pressure region in the combustion chamber to the relatively low-pressure region outside of the nozzle. Critical factors in nozzle design are the throat area and exit flare, the throat area being the major factor since it controls the rate of ejection of the gases. The exit flare angle is designed to follow the natural expansion of the gases as they pass from the nozzle throat to the atmosphere.

THEORY OF REACTION PROPULSION

Now that we have covered the general description of the liquid-propellant rocket motor, let us consider the nature of reaction propulsion, as well as its efficiency. The propulsive action of the rocket motor is described by the fundamental impulse-momentum equation, $F = \frac{mV}{t}$, solved for the resultant force in terms of the change of momentum of the propellants relative to the motor. The thrust force F, is measured in pounds; the propellant mass m, in slugs; the velocity of exhaust gases V, in feet per second; and the time interval t, in seconds. For example, a total mass of propellant consumed at the rate of 8 lb per sec and producing an effective jet velocity of 6600 fps will deliver a thrust of 1640 lb.

In considering the economy of operation of the liquid-propellant rocket motor, it is advisable to keep in mind the distinguishing characteristics of the motor as previously outlined. Whereas fuel consumption is the yardstick of economy of the air-stream and internal-combustion engines, propellant consumption is the basic measure used for the rocket motor. This factor, naturally, affects the calculation of specific consumption. Instead of computing pounds of thrust per pound of fuel per hour, we must compute pounds of thrust per pound of propellant per hour.

The efficiency problems of the rocket motor are the same as the conventional propeller-type power plant where the product of the thermal efficiency and propulsive efficiency is equal to the over-all efficiency. The thermal efficiency of both power plants is a function of the available energy for propulsion after the engine has converted the thermal energy of the fuel into output shaft horsepower or exhaust-jet energy as the case may be. The propulsive efficiency is a measure of the ability of the propeller or exhaust jet to convert available shaft or combustion energy (respectively) into propulsive effort.

In practice, the thermal efficiency may be determined by substituting measured thrust and propellant flow rate in the fundamental impulse-momentum equation $F = \frac{mV}{t}$ and calcu-

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Contributed by the Aviation and Oil and Gas Power Divisions and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

lating the effective jet velocity. Then the square of the ratio of effective jet velocity to theoretical jet velocity is the thermal efficiency. The theoretical jet velocity is based upon the available Btu content per pound of propellant mixture. The mixture used in this instance is ethyl alcohol (75 per cent) and liquid oxygen. It is important to note, referring back to our example, that at the present time we are able to turn but 28 per cent of the available Btu content into effective energy because of the molecular dissociation and cooling problem at high combustion-chamber temperatures. The thermal efficiency does not change with the velocity of the rocket but does improve with increasing altitude because of reduced atmospheric back pressure.

The propulsive efficiency is a function of the thrust, the velocity of the rocket relative to the ground, the net thermal energy, and the kinetic energy of the propellants by virtue of their motion relative to the ground. Fig. 2 shows a graph of the propulsive efficiency versus the ground speed of a rocket for a jet velocity of 6600 fps (4500 mph). It will be noted that as the ground speed approaches the velocity of the jet, a maximum efficiency of 100 per cent is obtained.

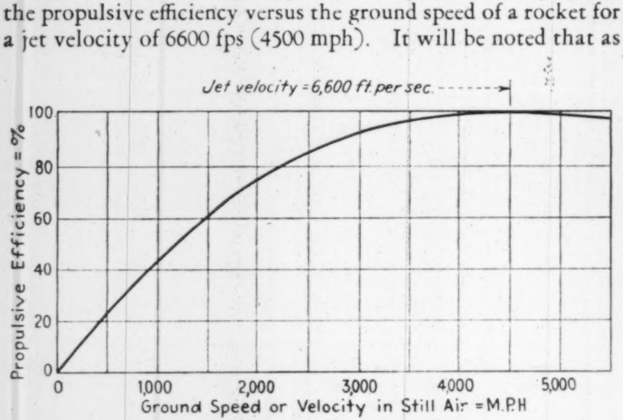


FIG. 2 PROPULSIVE EFFICIENCY VERSUS SPEED

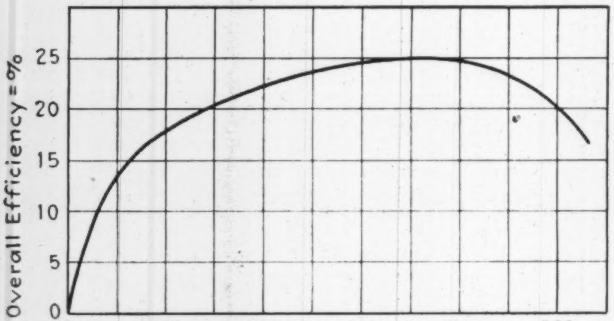


FIG. 3 COMPARISON OF OVER-ALL EFFICIENCY VERSUS SPEED FOR RECIPROCATING ENGINE WITH LIQUID-PROPELLANT ROCKET MOTOR

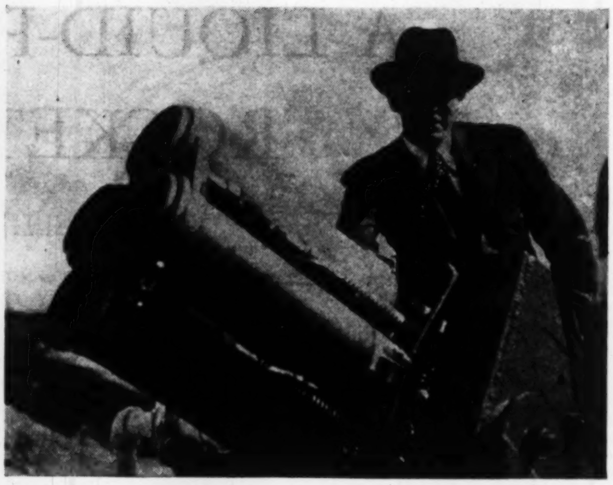


FIG. 4 LIQUID-PROPELLANT ROCKET MOTOR ON TEST STAND

FIG. 5 EXHAUST FLAME FROM ROCKET MOTOR

Fig. 3 shows a comparison of the over-all efficiency versus speed for a conventional engine with propeller, as compared with a liquid-propellant rocket motor. The efficiency scale is the same for both. The velocity scale of the rocket motor is 10 times that of the reciprocating engine. Surprisingly enough, the rocket motor has a better over-all efficiency than the best efficiency of the conventional type when it is operating in the proper speed range near its exhaust-jet velocity. This is possible because 100 per cent propulsive efficiency is attainable for the rocket where the airplane propeller utilizes about 80 per cent of the available shaft power. Since the rocket motor has a 25 per cent efficiency at 2750 mph, it can get the same mileage per pound of propellant mixture as the conventional-engine mileage per pound of fuel at 350 mph. Therefore the rocket can travel the same distance in about 10 per cent of the time.

There are of course many other variables affecting the picture of reaction propulsion but it is desirable to indicate the main potentialities in the light of present misconceptions of the operating efficiency of the rocket motor.

ROCKET MOTOR IN EARLY DEVELOPMENTAL STAGE

Since the development of this form of propulsion is only on the threshold of extensive progress, it is reasonable to assume that greater efficiencies than 28 per cent will be obtained in the near future.

Now let us take a look at a 1500-lb thrust unit performing on a test stand, Fig. 4. This 25-lb unit compares with a 1000-hp aircraft engine. The peculiar "beaded" nature of the exhaust flame, Fig. 5, is caused by the reflection of the burning gases from the relatively motionless surrounding envelope of air.

(*Continued on page 636*)

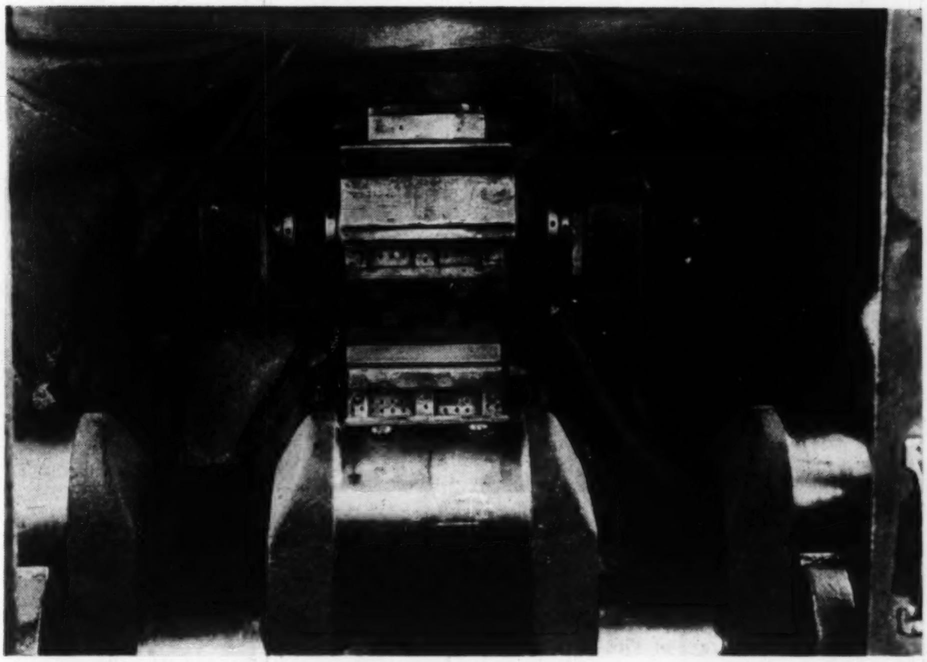


FIG. 1 INDUCTION-HEATING ARRANGEMENT FOR MAIN CRANKSHAFT BEARING

QUENCHING-WATER *Requirements* *of* INDUCTION-HEATED PARTS

By B. R. MILLER

STAFF ENGINEER, PLANT ENGINEERING DEPARTMENT, CATERPILLAR TRACTOR COMPANY, PEORIA, ILL. JUNIOR MEMBER A.S.M.E.

MANY parts used in products of the author's company are subjected to rough usage and extreme wear, making a hard heat-treated surface advantageous. Parts with longer life are thus obtained.

The parts to be processed require heat-treatment in certain sections only, and it is desirable to use medium-carbon steel. Medium-carbon steels require a water quench soon after the heating cycle since the allowable delay time between heating and quenching is short, owing to the absence of alloy in appreciable quantities. To this end induction equipment was purchased, as it seemed the best qualified to meet the conditions outlined.

AMOUNT OF WATER FOR QUENCHING HEAT-TREATED PARTS

Accurate information concerning the quantity of water required to quench a heat-treated part is practically unavailable. In the past the amount of water and the pressure required were determined by experience and cut-and-try methods. Experience as a guide was unreliable because of constantly changing conditions and the latter method proved to be costly. Hence, it was necessary to inaugurate a program to develop essential data that would yield enough facts to permit the design of systems whose performance could be foretold in advance with a reasonable degree of accuracy.

The parts quenched varied in weight from 336 lb to 2.6 lb and the heating cycle from 130 sec to 2.2 sec. The quench-water requirements varied from 807 gpm to 22 gpm. These figures are quite general and outline the scope of the tests only; they mean little in themselves. For this reason several representative examples are given in the following paragraphs to show the relation of water volume, water pressure, heat supplied, duration of heating-and-quenching cycle, and hardness obtained, together with illustrations of the parts tested.

The center main bearing of a crankshaft weighing 336 lb was quenched (see Fig. 1); 17.4 gal of water per quench being required at the rate of 141 gpm at 23 psi pressure for 7.4 sec. A Shore hardness range of 74–86 was obtained. Power at the rate of 337 kw for 8 sec supplied 2861 Btu to heat the surface. The quench water absorbed 164 Btu per gal to leave the part at a temperature of 240 to 320 F.

A final drive gear weighing 275 lb was quenched (see Fig. 2); 211 gal of water per quench were required at the rate of 384 gpm at 10 psi pressure for 34 sec. A hardness range of Rockwell C 59–64 was secured. Power requirements were 322 kw for 92 sec, supplying 28,101 Btu to heat the surface. The quench water absorbed 133 Btu per gal to leave the part at a temperature of 240 to 280 F.

A track-roller assembly weighing 55 lb was quenched (see

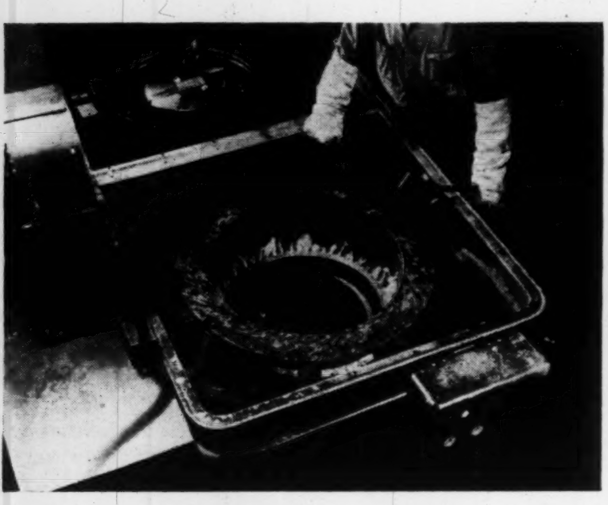


FIG. 2 QUENCHING A 275-LB DRIVE GEAR

Fig. 3); 101 gal of water per quench being required at the rate of 466 gpm for 13 sec. A hardness range of 2.45 to 2.75 mm Brinell was secured. Power at the rate of 376 kw for 65 sec supplied 23,184 Btu to heat the surface. The quench water absorbed 229 Btu per gal to leave the part at a temperature of 220 to 260 F.

The foregoing classes of parts were heated and quenched intermittently. Fig. 4 shows a continuous heating-and-quenching arrangement for track pins. The track pin weighed 2.6 lb; 52.8 gpm of quench water was supplied at 6 psi pressure. A minimum hardness of Rockwell C 60 was secured. Approximately 125 kw was supplied to heat the surface. The pin movement was 10.6 ipm and the pin length was $6^7/_8$ in. The Btu supplied per pin were 4624 and the quench water supplied per pin was 34.3 gal. The quench water absorbed 134 Btu per gal to leave the part at a temperature of 180 to 220 F.

OPERATING PROCEDURE

The various quenching systems operating in production were utilized to obtain the information desired. Appropriate valves were closed to check the system for leaks. If no drop was observed in the measuring tank after 1 min, the system was accepted as tight. The tank level was determined. A specified number of quenches were made with only one quench fixture operating, and the level determined again. The difference in the initial and the final level represented the water used in making the quench.

Two readings were obtained for each point considered. The pressure at which the readings were taken was approximately the same as under actual operating conditions. The float bulbs were out when measuring the water so that the elevating pumps would not operate. In all cases, the cold well in each system was used as the measuring tank. The valves, gages, pumps, and other equipment utilized in this test were already in use on the various units.

Because of the many variables present, it was necessary to test each type of part requiring heat-treatment. The water requirements of the various sizes of the same-type part could be estimated with reasonable accuracy after the water requirement of one was known.

CONCLUSIONS

The test has brought to the fore the fact that quenching-water pressure, volume, and the quench fixture itself are the three major items that determine the effectiveness of the quench.

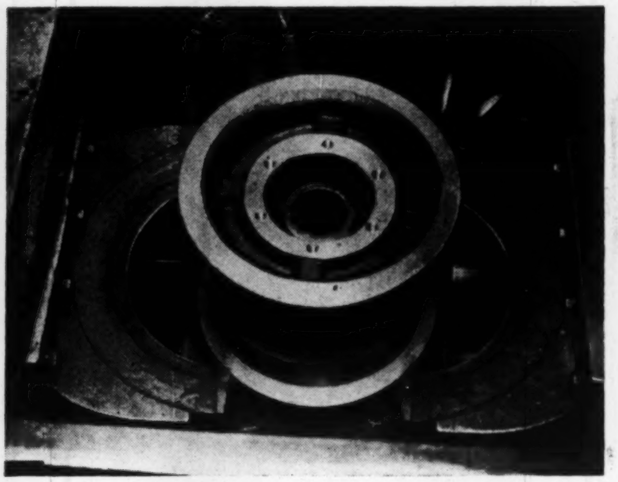


FIG. 3 SET UP FOR HEAT-TREATING AND QUENCHING A TRACK-ROLLER ASSEMBLY

Additional work is contemplated to determine more accurately the relationship of the three items. Until better data are obtained, those mentioned in the foregoing will have to suffice. The quenching fixtures used can best be evaluated by inspecting Figs. 1 to 4.

This information is passed on for what it may be worth to the reader, with an invitation for constructive criticism or comment by those who have had experience along the same lines.

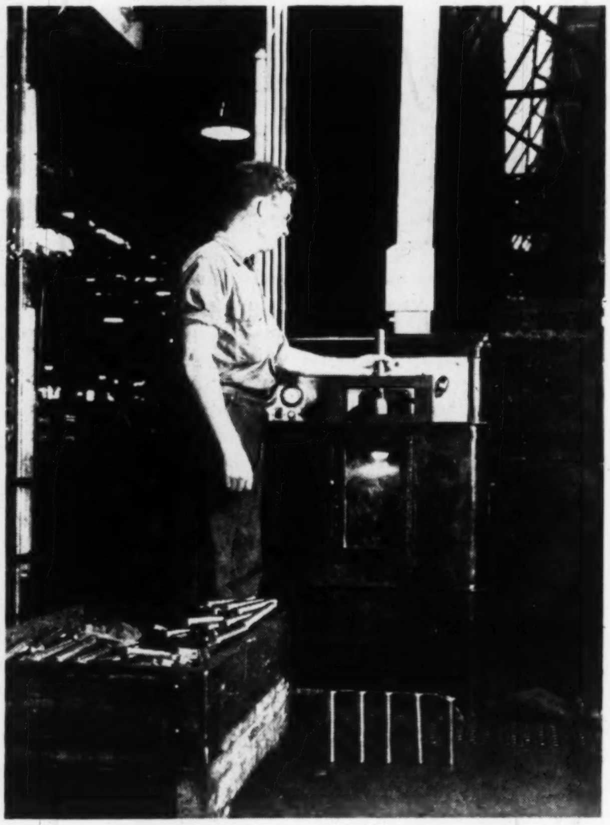
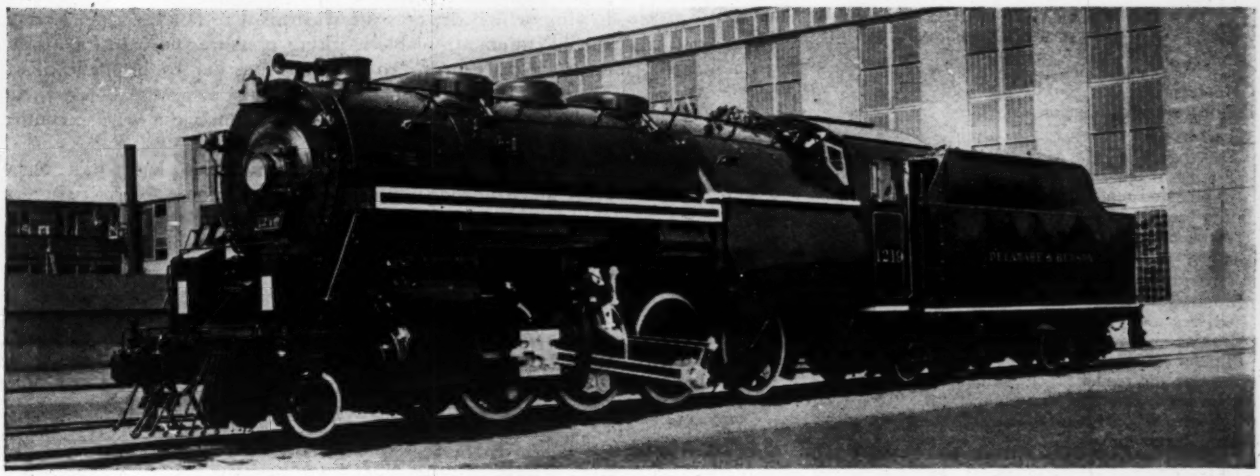


FIG. 4 CONTINUOUS HEATING-AND-QUENCHING ARRANGEMENT FOR TRACK PINS



DELAWARE AND HUDSON LOCOMOTIVE NO. 1219 FITTED WITH FUSION-WELDED BOILER

FUSION-WELDED BOILER *on* D.&H. LOCOMOTIVE

By G. S. EDMONDS

SUPERINTENDENT OF MOTIVE POWER, THE DELAWARE AND HUDSON RAILROAD

ON March 11, 1936, after a preliminary co-operative study with the American Locomotive Company covering a period of 5 years, The Delaware and Hudson Railroad Corporation obtained the approval of the Interstate Commerce Commission to purchase from the American Locomotive Company, for the purpose primarily of experimentation, one fusion-welded locomotive boiler. This type boiler was presumed to possess certain improvements as follows, in comparison with the riveted type:

1 Reduction to a minimum of caustic embrittlement.

2 Smooth interior surface, permitting maintenance of a clean boiler.

3 Pitting dangers reduced.

4 Weight reduction.

5 Elimination of concentrated stresses in rivet zone, etc.

This welded boiler is of the wide-firebox radial-stayed type, with a sloping backhead, having a working pressure of 225 psi. It was applied to a consolidation-type locomotive No. 1219 which was placed in service on September 24, 1937. The principal characteristics of this locomotive are given in Table 1.

The boiler was built to American Locomotive Company drawings 130-S-65352 and 138-S-65352, a general description, particularly with reference to the welding follows.

DETAILS OF WELDED CONSTRUCTION

The process of welding in the construction of the boiler shell was in accordance with the requirements of the rules for the fusion process of welding of the American Society of Mechanical Engineers Code for Power Boilers.

A factor of safety of 5 obtains in the welded joints, based on a joint efficiency of 90 per cent of the lowest tensile strength of the plate. The factor of safety of all other parts is in conformance with the established Laws, Rules, and Instructions for Testing of Steam Locomotives and Tenders and Their Appurtenances issued by the Interstate Commerce Commission, Bureau of Locomotive Inspection.

The front tube sheet consists of a circular plate welded against a ring which is fillet-welded to the boiler shell. The ring is provided with slots at the top and bottom centers so that the tube sheet can be removed and renewed without cutting any welds except those directly attaching the tube sheet to the circular ring.

The dome, 33 in. I.D., is flanged from one piece of plate $1^1/_{16}$ in. thick, the bottom flange being fitted to the shell and attached with a double butt weld. The dome-liner reinforcement is $1^1/_8$ in. thick, flanged, and extending upward into the dome and attached to the dome and boiler by fillet welds at the edges of the liner.

The backhead is $^9/_{16}$ in. thick, of normal design except that the flange is made sufficiently deep to permit the location of the welded joint between two rows of stay bolts.

The firebox ring is of cast steel of U-shape cross section with the flanges projecting upward, thereby permitting the attach-

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Contributed by the Railroad and Metals Engineering Divisions and presented at the Spring Meeting, Chattanooga, Tenn., April 1-3, 1946, of The American Society of Mechanical Engineers.

TABLE 1 CHARACTERISTICS OF D.&H. LOCOMOTIVE EQUIPPED WITH FUSION-WELDED BOILER

Class	E-6-A (2-8-0)
Cylinders, in.	27 × 32
Driving wheels, diameter, in.	63
Wheel base:	
Driving, ft-in.	17-6
Engine, ft-in.	26-11
Engine and tender, ft-in.	$64\text{-}6\frac{3}{4}$
Boiler pressure, psi	225
Tractive effort, lb	72000
Factor of adhesion	3.75
Weight, lb:	
Engine truck	31400
Drivers	269800
Engine	301200
Tender ($\frac{2}{3}$ load)	155500
Engine and tender	456700
Boiler inside diameter, first course, in.	$85\frac{7}{8}$
Firebox, length × width, in.	132 × 114
Tubes, number	316
Tubes, outside diameter, in.	2
Flues, number	46
Flues, outside diameter, in.	$5\frac{3}{8}$
Tube and flue length, ft-in.	$13\text{-}9\frac{1}{2}$
Evaporating surface, sq ft	
Tubes	2282
Flues	869
Firebox	286
Arch tubes	66
Total	3503
Superheating surface, sq ft	735
Grate area, sq. ft	104.5
Tender capacity:	
Water, gal	9000
Coal, tons	20

ment of the ring to the firebox sheets by the bottom row of stay bolts. The edges of the sheets are joined with the firebox ring by fillet welds.

Pads for the insertion of studs, boiler-check flanges, washout-plug bushings, angles for dry-pipe support, and front tube-sheet ring are welded to the shell, while all other attachments are threaded, studded, or riveted. Boiler-brace feet are riveted to the shell and front tube sheet and backhead.

The shell course is of $1\frac{1}{16}$-in. special low-carbon-steel plate. Longitudinal and circumferential seams are double butt welds. The throat sheet and top connection between shell and firebox wrapper is $1\frac{3}{16}$-in. plate. The firebox wrapper is $\frac{5}{8}$ in. and the backhead $\frac{9}{16}$ in. thick, the backhead flange being deep enough to bring the welded seam between two rows of stay bolts.

STRESS-RELIEVING AND INSTALLATION OF BOILER

The boiler was built at the Dunkirk, N. Y., plant of The American Locomotive Company, welded seams being examined by x ray. After the completion and assembly of the shell and outside firebox, it was shipped to The Combustion Engineering Company, Chattanooga, Tenn., for stress-relieving, being placed in a furnace and the temperature gradually brought up to 1100 to 1150 F, held for $2\frac{1}{2}$ hr, and then allowed to cool down in the furnace. Before the boiler shell was placed in the furnace, the firebox ring was bolted in place as a stiffening member, and the flat and circular parts of the wrapper sheet were thoroughly braced to prevent distortion. The stress-relieving was accomplished without any measurable change in contour.

The boiler was then sent to the Schenectady plant of The American Locomotive Company where the inside firebox and tubes were applied. After completion, the fusion-welded boiler was subjected to hydrostatic test of $1\frac{1}{2}$ times the maximum allowable working pressure and while subjected to this pressure was given a thorough hammer and impact test, following which the pressure was raised to not less than 2 times the maximum allowable working pressure and held for a sufficient length of time to enable inspection to be made of all joints and connections. Finally, an inspector entered the boiler and the interior surfaces and connections were examined thoroughly.

The boiler was shipped from the builder's plant to The Delaware and Hudson Company shops at Colonie, N. Y., where it was used as a stationary boiler without lagging and jacket, for a period of 6 weeks for observation and check before mounting as a locomotive boiler.

SERVICE TESTS AND INSPECTIONS

At the conclusion of this 6-week period, the boiler was mounted and the locomotive was placed in service subject to boiler inspections, tests, and reports as follows for the first 5 years:

In the first year, the lagging and jacket were removed and shell joints examined each 3 months.

In the second year, the same procedure obtained each 6 months, and yearly thereafter up to 5 years' service.

It was also required that when the hydrostatic test was applied the pressure should not be less than $1\frac{1}{2}$ times the maximum allowable working pressure.

Other than as specified, the boiler is equipped, inspected, tested, and maintained in accordance with the established rules for the inspection and testing of steam locomotives and tenders and their appurtenances.

Inspections were made in accordance with Federal requirements governing this specific project, the reports of inspections being as follows for the five-year period:

First Quarter. Locomotive No. 1219 was taken out of service at Colonie, N. Y., December 19, 1937, for the first 3 months' inspection of the fusion-welded boiler. The jacket and lagging were removed to enable thorough inspection of welded seams. A pressure of 225 psi was applied and a careful inspection was conducted of all welding in the shell, wrapper and firebox sheets, and same were found in good condition.

Second Quarter. Locomotive No. 1219 was taken out of service at Oneonta, N. Y., March 19, 1938, for the second 3 months' inspection of the fusion-welded boiler. The jacket and lagging were removed to enable complete inspection of all welded seams. Pressure of 225 psi was applied and a thorough inspection made of all welding of shell, wrapper, and firebox sheets of the boiler, same being found in good condition.

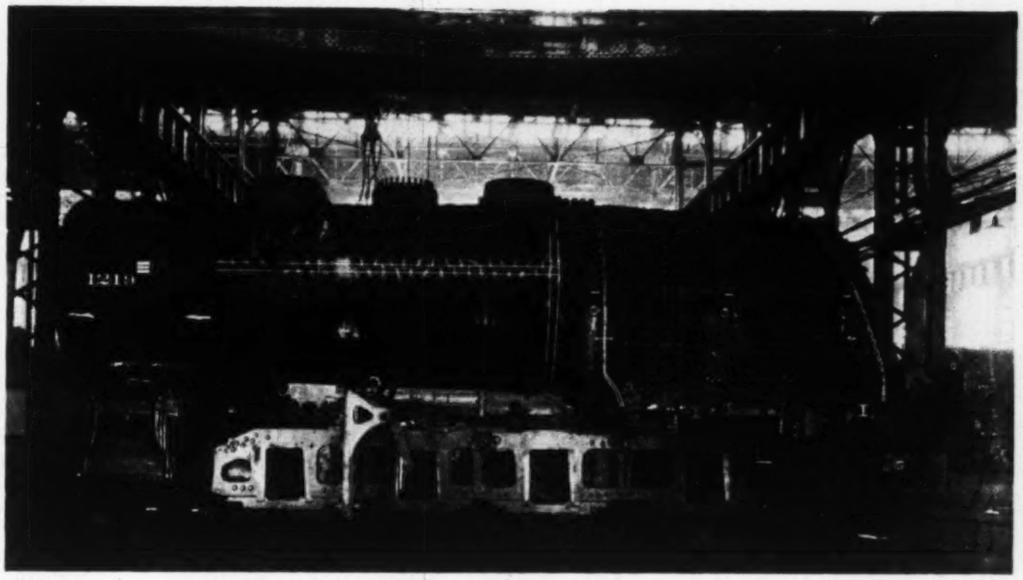
Third Quarter. Locomotive No. 1219 was held at Oneonta, N. Y., for the third 3 months' inspection of the fusion-welded boiler. The jacket and lagging were removed, in order that a complete inspection could be made of welded seams. Pressure of 225 psi was applied and careful examination made of all welding of shell, wrapper and firebox sheets, all of which were found in good condition.

Fourth Quarter. Locomotive No. 1219 was held at Oneonta, N. Y., September 17, 1938, for the first annual test and inspection of the fusion-welded boiler. The jacket and lagging were removed to enable thorough inspection of welded seams. Hydrostatic test was applied at a pressure of 340 psi and careful inspection made of all welding of shell, wrapper, and firebox sheets on September 20. All welding was found to be in good condition.

During the first year of the 5-year test period, the locomotive made approximately 75,000 miles in road service. The expectancy of the project had to date been fully realized, and the period of concern, if extant, had passed.

In the second year of service, the specified semiannual inspections were made.

First Half of 1939. Locomotive No. 1219 was held for the



SHOP VIEW OF FIREBOX AND OF FUSION-WELDED BOILER

first semiannual inspection and test in the second year of service, hydrostatic test being applied at a pressure of 340 psi at the Colonie Shops, April 3, 1939. Careful inspection was made of all welding of shell, wrapper and firebox sheets and same found to be in good condition.

Second Half of 1939. Locomotive No. 1219 was held for the second semiannual inspection and test in the second year of service, hydrostatic test at a pressure of 340 psi being applied at Oneonta, N. Y., November 17, 1939. Careful inspection was made of all welding of shell, wrapper and firebox sheets and same found to be in good condition. The accumulated mileage at the end of the second year of the 5-year test period was 131,635 miles.

Third Annual Inspection. Locomotive No. 1219 was held for annual inspection and test in the third year of service, hydrostatic test at a pressure of 340 psi being applied at Colonie Shops, July 9, 1940. Careful inspection was made of all welding of shell, wrapper and firebox sheets and same found to be in good condition. The accumulated mileage at the third annual inspection was 168,133 miles.

Fourth Annual Inspection. Locomotive No. 1219 was held for the annual inspection and test for the fourth year of service, hydrostatic test at a pressure of 340 psi being applied at Colonie Shops, July 3, 1941. Thorough inspection was made of all welding of shell, wrapper, and firebox sheets and same found to be in good condition. The accumulated mileage at the time of the fourth annual inspection was 214,485 miles.

Fifth Annual Inspection. Locomotive No. 1219 was held for inspection and test for the fifth year of service, hydrostatic test at a pressure of 340 psi being applied at Colonie Shops, August 15, 1942. Careful and complete inspection was made of all welding of shell, wrapper and firebox sheets and same found to be in good condition. The accumulated mileage at the time of the fifth and final specified test was 268,905 miles.

During the five-year test period all hydrostatic tests were made at a pressure of 340 psi or $1^{1}/_{2}$ times the maximum allowable working pressure. In July, 1943, we were advised by the Director of the Interstate Commerce Commission that in the future, compliance with Rule 17 of the Laws, Rules, and Instructions for Inspection and Testing of Steam Locomotives and Tenders and Their Appurtenances would be satisfactory, that is, hydrostatic test 25 per cent above maximum allowable working pressure.

Subsequent to the 5-year test period, hydrostatic tests were applied and annual inspections were made as follows:

September 23, 1943, after accumulating 304,954 miles
November 3, 1944, after accumulating 337,836 miles
October 26, 1945, after accumulating 368,120 miles
January 23, 1946, while in shop for class repairs, 372,565 miles

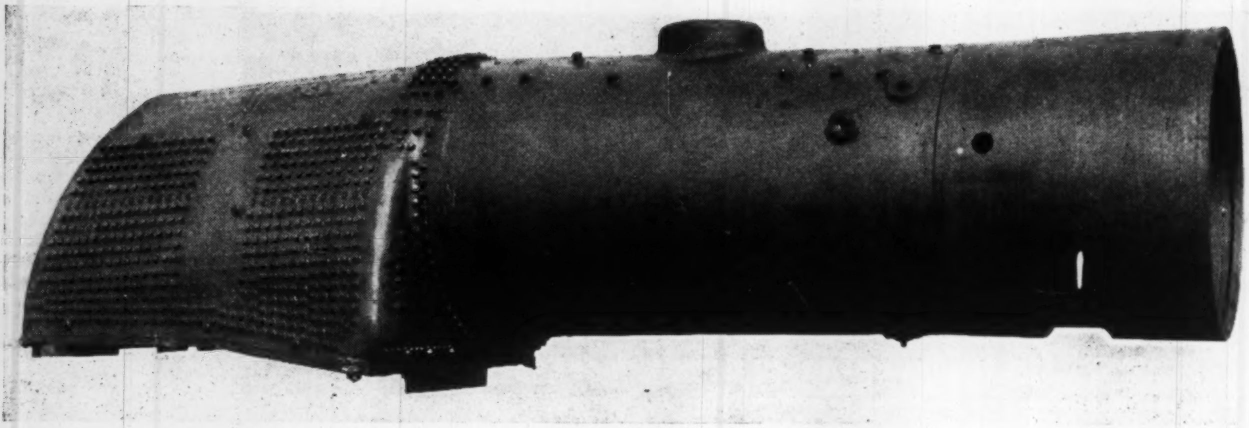
REPAIRS AND RENEWALS REQUIRED

At the time the locomotive was shopped in September, 1943, a new firebox tube sheet and new firebox throat sheet were applied after a mileage of 304,954 miles. It is of interest to note that a check of seventeen other locomotives of the same class showed these sheets were renewed at an average of 193,000 miles.

In the matter of work done on the shell portion of the welded boiler, none has been found necessary as there has not been even the semblance of any weakness in welded seams or in any other parts of the shell construction after approximately 378,000 miles. While there is no record available to show the amount of calking performed on the 19 other boilers of this class which are of riveted construction, it is of interest to note that 6 of these boilers received shell attention at an average of 376,000 miles. Two of these were renewals of dome butt straps serving as portion of seam outer straps; 3 were renewals of dome liners which provided inner seam straps; and the other comprised complete new dome and seam outer strap.

The locomotive was used in road service on the Pennsylvania and Susquehanna Divisions between Wilkes Barre and Oneonta, a run of about 130 miles each way, from September, 1937, to October, 1942, and with the receipt of new power, this locomotive was assigned to the Pennsylvania Division for operation between Wilkes Barre and Carbondale with the other locomotives of this class.

After $8^{1}/_{2}$ years of road service and approximately 378,000 miles, the records would indicate that the performance of this fusion-welded boiler has fully met all expectations, and application of another fusion-welded boiler has been arranged for one of the 4-6-6-4 type locomotives under consrruction by The American Locomotive Company. This boiler will have three barrel courses, the largest being $102^{1}/_{8}$ in. O.D., shell $1^{5}/_{16}$ in. thick, over-all length 59 ft 6 in. and 285-psi working pressure.



WELDED BOILER FOR DELAWARE AND HUDSON RAILROAD LOCOMOTIVE

LOCOMOTIVE BOILERS—WELDED CONSTRUCTION

By JAMES PARTINGTON

MANAGER, ENGINEERING DEPARTMENT, AMERICAN LOCOMOTIVE COMPANY. MEMBER A.S.M.E.

THIRTY years ago both oxyacetylene and electric-arc welding were used in our railroad shops on boilers for new work and repairs, and on locomotive and car parts chiefly in making repairs. Sometimes this welding was not applied wisely and the results were unsatisfactory. This was definitely the case in welding when it was used on the shell of a locomotive boiler.

On account of stress concentrations, a crack sometimes develops in a locomotive-boiler shell and this must be repaired by applying a riveted patch. However, in the early days of welding such a crack was oftentimes chipped out more or less properly, and then electric-arc welding was used to seal up the groove. This welding could be applied only from the outside, and it was not stress-relieved because the necessity and advantages of stress-relieving were not then realized. When a locomotive having a boiler with this sort of a weld went back into service a new and more serious crack soon appeared and the locomotive was ordered out of service. If this sort of repair were made in the stay-bolted area of the backhead, and a new failure occurred, the result was sometimes serious injury to the fireman or others.

These misapplications of welding made it imperative that the Bureau of Locomotive Inspection of the I.C.C. prohibit welding on locomotive boilers except in the firebox, and then only as high as 14 in. below the highest part of the crown sheet.

In this period good welding and poor welding were both done, but a sufficient amount of good welding was accomplished mostly on pressure vessels to demonstrate the great advantages that could be obtained by the proper use of welded construction.

FORMULATING A CODE OF SAFE WELDING PRACTICES

In 1918 the Boiler Code Committee of the A.S.M.E. appointed a subcommittee on welding to draft rules for safe welding practices. In 1920 this subcommittee requested the American Welding Society to appoint a conference committee to work with it in drafting these welding rules.

This proved to be a difficult task which required nearly 5 years of intensive effort by the two committees. The welding rules which they proposed were presented to the Boiler Code Committee which approved them, followed by Society approval in 1925, when they were incorporated in the first edition of the Code for Unfired Pressure Vessels.

The use of these rules, especially the requirements for the x-ray examination and stress-relieving of welded joints, resulted in very definite improvements in welded construction, and in 1931 these rules were added to the Code for Power Boilers.

On the request of the Mechanical Committee of the Association of American Railroads (A.A.R.), these welding rules were added to the Code for Boilers of Locomotives in 1942.

After the welding rules were issued the use of welded construction was greatly accelerated in the production of boilers and unfired pressure vessels of all sorts for stationary service. In the railroad field, however, the early unfortunate results of welding wrongly applied still deterred progress.

ALL-WELDED LOCOMOTIVE BOILER OF THE D.&H. RAILROAD

On the application of the late L. F. Loree, then president of the Delaware & Hudson Railroad Company, permission was granted for the operation of a locomotive with an all-welded boiler, if the requirements of the Bureau of Locomotive Inspection of the I.C.C. were complied with, and if the design and construction procedure were approved by the Mechanical Division of the A.A.R.

This boiler was built in accordance with the rules of the A.S.M.E. Code for Power Boilers and placed in service in the fall of 1938, on the Delaware & Hudson Railroad. The rules for power boilers were used because at that time no welding rules were embodied in the Code for Boilers of Locomotives.

Contributed by the Railroad and Metals Engineering Division and presented at the Spring Meeting, Chattanooga, Tenn., April 1-3, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The operation of this welded boiler was permitted as an experimental installation, and the condition of the welded joints was examined every 3 months during the first year of operation, every 6 months during the second year, and yearly since that time.

The welded joints on this boiler have developed no leaks and no repairs on the shell have been necessary in over 7 years of service. When the repairs necessary in the boiler shells of locomotive boilers of riveted construction are considered, the saving in the elimination of repair costs, and the greater availability of this locomotive for continuous service are items of great importance. On some railroads the cost of repairs to the shell courses of riveted boilers is a very heavy item of maintenance expense.

BOILER AS STIFFENING MEMBER IN LOCOMOTIVE STRUCTURE

The locomotive boiler functions primarily as a pressure vessel but also to a considerable extent as a beam because it is the principal stiffening element in a long structure which is supported on springs and is subject to many vibrational shocks.

The magnitude of these shocks depends upon many variables, some of which are as follows:

1 Speed of the locomotive.
2 Character of the track.
3 Shocks due to the application of the brakes.
4 Sometimes unknown stresses due to collision or derailment.

Therefore let us compare the barrel portion of the locomotive boiler, riveted versus welded construction.

The barrel or circular portion in a riveted boiler usually consists of two or three separate courses riveted together with double-riveted circular seams having an efficiency factor of about 65 per cent. Considered as a beam, this interrupted continuity of section is an element of weakness for two reasons, as follows:

1 The reduction in strength at the circular seams.
2 The offset from a straight line at these lapped seams.

These offsets are focal points for concentration of stresses which in combination with other causes, such as caustic embrittlement, produce progressive fractures, generally in the form of cracks at or near these lapped seams.

The circular seams in the barrel courses of welded boilers are double-welded butt joints which under test show 100 per cent efficiency; and, what is of more importance, considered as a beam, the continuity of the structure is completely maintained.

Some of the advantages to be gained by the use of welded boilers for locomotives may be summarized as follows:

1 The elimination of riveted joints which are likely to have some seepage between the boiler plates even when the best possible fabricating technique is employed.

2 Elimination of boiler leaks, removing the possibility of cracked sheets which are frequently a major item of maintenance cost especially when high boiler pressures and high operating speeds are involved.

3 The smooth contour of a welded boiler permits a much easier and generally more satisfactory application of the boiler lagging and jacket, and provides this same smooth surface on the inside, which contributes to easier and more satisfactory washing-out operation.

4 On many modern locomotives the saving in weight of the welded design versus the riveted type is an important item. This saving will vary with the size and type of locomotive and may be from 3000 to 6000 lb for the boiler alone, with some small incidental additional saving in weight of lagging and jacket.

BOILER-CODE WELDING REQUIREMENTS

Welded seams having a tensile strength and elongation equal to or better than the parent metal, are obtained by following the Welding Procedure given in Section 9 of the A.S.M.E. Boiler Code rules. This procedure calls for the qualification of the welding technique of the shop involved and covers definitely the shop welding apparatus, electrodes, and plate material.

Methods of stress-relieving that are employed and the test specimens must meet all the requirements for Class 1 welding as covered in the Code for Welded Boilers for Locomotives.

After the shop methods have been approved the qualification of individual welding operators must be obtained by testing each welder who must follow the exact shop welding technique that has already been approved. The tests for welding operators are specially devised to establish the operator's ability to produce sound welds in the positions involved in the actual welding of the boilers.

In so far as possible, down-position welding is arranged for, and the smothered-arc type of machine welding is extensively employed.

The foregoing is the groundwork or preparation carried out before the job is started. Next, test specimens must be furnished for each boiler, and these specimens must meet all of the requirements.

All of the strength welds must be x-rayed and must show the required degrees of soundness; freedom from inclusions or porosity.

After the welded boiler has passed the x-ray examination successfully, it is stress-relieved in a furnace of sufficient size to take the boiler as a unit. This furnace must be under pyrometer control and must show a closely uniform temperature at all points. The test specimens are subjected to the same heat-treatment, preferably with the boiler.

After the firebox has been applied and the boiler completed, a hydrostatic test pressure of $1^1/_2$ times the working pressure is applied, and under this pressure, all of the welds are subjected to a hammer test.

In the fabrication of a welded boiler nothing is left to chance; all of the code rules are carefully followed, and the result obtained can reasonably be expected to be approximately 100 per cent.

In the manufacture of a welded boiler, the welding process must be the proper one for the material being welded. Alloy steel, for example, requires a different procedure, from that employed in welding ordinary carbon-steel boiler plate of 55,000 psi tensile strength. High-carbon high-tensile steel also requires a different procedure.

WELDED BOILERS BUILT FOR WAR DEPARTMENT

During the war the production of steam locomotives for the U. S. War Department was considerably increased by the fabrication of about 300 boilers with double-welded butt joints for the longitudinal seams of the barrel courses. This eliminated about 20 ft per boiler of octuple-riveted seams with inside and outside welt straps, and relieved the overload on the boiler-shop hydraulic riveters which was the bottleneck in the author's plant in Schenectady.

This welding was all machine-welding, x-rayed and stress-relieved and is, we believe, the first large-scale application of code welding on locomotive boilers.

The longitudinal seams only were welded because at that time the plant did not have a stress-relieving furnace large enough to accommodate the complete boiler. Such a furnace has since been built and the largest locomotive boilers can now be stress-relieved as a completely welded unit.

Thus far the welded locomotive boilers that have been built or for which designs have been approved have head bracing attached by rivets. One of the next forward steps will be bracing attached by welding before the boiler shell is stress-relieved.

After the boiler shell is stress-relieved the firebox is applied and all flexible stay-bolt sleeves and stay-bolts are applied in the same manner as that followed in riveted-boiler construction.

The only difference in the final steps in producing the completed boiler is that for a welded boiler the hydrostatic test pressure is $1^{1}/_{2}$ times the design pressure, whereas for the riveted boiler it is $1^{1}/_{4}$ times the design pressure.

With the ending of the war a number of orders have been placed for welded locomotive boilers and additional orders are pending. When these welded boilers are ordered in sufficiently large quantities to justify the maximum employment of positioning devices and the maximum use of machine welding, the cost of these superior boilers will be reduced to a point where it will compare favorably with the cost of riveted boilers.

The use of welded locomotive boilers will greatly reduce the charges for boiler maintenance in railroad shops and also greatly reduce the time that locomotives are out of service on account of boiler repairs.

PROSPECTIVE USE *of* FUSION-WELDED LOCOMOTIVE BOILERS

By JOHN M. HALL

DIRECTOR, BUREAU OF LOCOMOTIVE INSPECTION, INTERSTATE COMMERCE COMMISSION, MEMBER A.S.M.E.

THE purpose of the Bureau of Locomotive Inspection is to promote the safety of employees and travelers on railroads; and the interest of the Bureau in the matter of boiler construction, whether riveted or fusion-welded, is therefore wholly that of safety.

Inasmuch as no property loss or personal injury or death has occurred in many years because of failures of riveted joints in locomotive boiler shells, some of which have been in service for periods of time exceeding the general life range of human beings, it is not apparent that safety would be increased by the use of fusion-welded joints in these boiler shells. Consequently our part in the acceptance or rejection of applications for consent to the use of welded boilers for locomotives that come within the jurisdiction of the Locomotive Inspection Act is to obtain, in so far as possible, reasonable assurance that welded boilers constructed for use on locomotives will comply with the terms of the Act; in brief—no part of any locomotive shall present unnecessary peril to life or limb.

Because of well-known reasons which need not here be discussed this assurance with respect to welded boilers was not possible prior to the general use of the A.S.M.E. welding codes, particularly that part of the Power Boiler Code which has to do with the construction of boiler drums and shells by welding, and favorable experience of users of these boilers and various authorities charged with the enforcement of safety rules.

Welded locomotive boilers will not just come to the railroads without effort on their part. It is necessary under the terms of the Locomotive Inspection Act that adequate safety be built into all boilers used on locomotives and, if we have proper evidence, through the filing of applications accompanied by drawings and specifications for consent for use by any railroad or railroads desiring to use welded boilers, that the required degree of safety will be provided, there will be no objection on our part to such use.

The first application for consent for use of a welded locomotive boiler that conformed to the procedure required by the Locomotive Inspection Act for changes in the rules to authorize this method of construction, together with a specification which after some adjustments complied with the then recognized code for fusion-welding of boiler shells, was filed by the Delaware and Hudson; this boiler has been described by G. S. Edmonds.[1] A subsequent application, with specification, was received from this company and consent for use of this boiler was given, but war work interfered with proceeding with construction at that time. After hostilities ceased this application, together with a specification, revised to include some changes in the art that had occurred in the meantime, was reinstated and consent for use of the boiler was given. It is understood that this boiler is now under construction.

Applications from two other railroads were received and, after some adjustments in the specifications to have these boilers conform in general to successful constructions used in other fields so that reasonable assurance of continuous integrity was provided, consent was given for use of these boilers. An application from another railroad, covering several boilers, was received, but because of vagueness or lack of clarity in some of the items in the specification and other matters it was necessary to defer giving our consent. This railroad in common with others, when informal inquiries as to our position in the matter of use of welded boilers were made, was advised to the effect that we were not averse to the use of fusion-welded boilers by any railroad provided such boilers are safe within the intent of the Act; that the provisions of the Act are such as to make it mandatory that any boilers to be put into service shall be known to be as safe as those of conventional construction now in general use; and that the critical construction features of the proposed boilers should not vary materially from current practically standard constructions of welded boilers and should have a background of successful use in steam boilers operating within the jurisdiction of a duly constituted steam-boiler authority. The railroad was further advised that we would give consideration to renewal of its application if the specification and drawings are revised to provide assurance that the proposed boilers would conform to the foregoing.

It should be understood by all railroads contemplating use of welded boilers that the specification, irrespective of by whom prepared, submitted by them to the Bureau, along with their application for consent for use of such boilers, is necessarily accepted as the railroad's specification and if the contemplated boiler is put into service the railroad is wholly responsible for the safety thereof. This feature seems to have been overlooked in some instances; however, the Act and the rules promulgated

(*Continued on page 629*)

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[1] "Fusion-Welded Boiler on D.&H. Locomotive," by G. S. Edmonds, pp. 619–621 of this issue.

Limits of FACTORS *of* SAFETY *in the* HUMAN BODY

By EUGENE F. DU BOIS[1]

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THE necessity for providing large factors of safety has long been recognized by engineers. It is, however, not impertinent to call attention to the fact that the principle was well taken care of by nature in its development of the human body. Man has two kidneys and he can survive with half a kidney. He has five lobes in his lungs and can live with one lobe, provided it be a good one. Most of the bones, ligaments, and tendons will stand loads much greater than required by ordinary conditions of life.

There are, nevertheless, fairly well-defined limits to these factors of safety. In some few parts of the body they are dangerously small; for example, the blood vessels of the brain and heart and the narrow air passage at the vocal cords. The brain is fairly well protected from blows but even primitive man learned that certain parts of the skull were weak, and he discovered the best places to apply his stone axe.

Disease is nothing but an encroachment upon the human factors of safety. In patients seriously ill, physicians see one organ after another reduced in its functional capacity until somewhere in the body the limit is reached and the patient dies.

HUMAN PHYSIOLOGY LIMITS IN AIRCRAFT DEVELOPMENTS

In the last few years we have become aware of the fact that the human physiology is the limiting factor in the development of many machines, particularly airplanes and tanks. It is for this reason that we physiologists, psychologists, and surgeons wish to present our point of view to the mechanical engineers. We hope that they will consider man as a vital part of the machine with definite limits in structure and function. We can even hope that the machine will be planned from the man outward, considering the instruments and controls to be extensions of the man's nervous system (1).[2]

Let us take as examples some of the problems presented by the new planes that approach the speed of sound. When they turn at such speeds they develop great centrifugal force of considerable duration, say, 6 to 8 g for 10 sec. If the pilot is in the conventional sitting position, the blood is centrifuged from his head to the lower part of his body and he becomes unconscious. If the pilot is in the prone position, lying on his face, he can stand much more g but this is a very dangerous position for the take-off when the rapid acceleration pulls the blood from his head down toward his feet.

Again the rapid ascent lifts the pilot in a few minutes to altitudes in which the pressure is so low that he suffers from lack of oxygen even when breathing 100 per cent oxygen through a mask. He is also in great danger of the bends, aeroembolism. These hazards can be avoided by a pressure cabin, but a bullet or any other damage to the vulnerable plastic canopy results in explosive decompression. This means a terrific drop in pressure and a return to the lethal environment in about $^1/_{10}$ sec. Unless the author is greatly mistaken the engineers will find themselves balked in their otherwise logical developments by the sharp limits of human endurance.

Let us consider in greater detail the subject of blackout in dives and turns. Our muscles and many other tissues can function for minutes or even hours with little or no oxygen. This is not the case with the brain. If an air cuff is applied around the neck and suddenly inflated, the man becomes unconscious in less than 15 sec because the blood flow with its oxygen is stopped abruptly. Unless the flow is resumed within 8 minutes the damage is irreversible. The retina of the eye is even more rapid in its response to lack of blood. As a result the first effect of a sharp turn in an airplane or in the pull-out of a dive is felt in 3 or 4 sec. There is a dimming of vision, then complete loss of vision; then if the g is above 5 or 6 a loss of consciousness in 8 or 10 sec followed by recovery in the reverse order as the g diminishes.

Most pilots can stand 4 g for 6 sec without suffering complete loss of vision and 5 g for 7 to 8 sec without loss of consciousness. They can stand $1^1/_2$ to 2 more g if provided with the modern types of pressure suits, with air bladders over the legs, thighs, and abdomen, that inflate automatically and press hard enough to keep most of the blood in the upper part of the body so that the heart can pump it back to the head.

The serious effects can be realized of negative g applied in inverted turns where the blood is centrifuged toward the head. Forces of 3 to 4 g for more than a few seconds cause such congestion that there is first red vision then irreparable damage to the brain, but much higher forces can be tolerated for a fraction of a second. It is entirely possible for the engineer to calculate the permissible g forces and their durations. He must not expect his plane to exceed these limits unless he expects to get along without a pilot.

If pressure cabins are not used there will be danger of bends in altitudes over 35,000 ft, or even 30,000 ft. Our blood and body tissues at sea level contain about 1000 cc of nitrogen gas (2). When the pressure of the air is reduced at 33,000 ft to one quarter of the pressure at sea level, the nitrogen begins to go out of solution and form small bubbles in the blood vessels and tissues. This can be prevented if the pressure inside the cabin corresponds to that of an altitude below 25,000 to 30,000 ft. If such a cabin, pressurized at a more comfortable level of, say, 10,000 ft, is badly punctured or broken at 45,000 ft, there is an explosive decompression that causes a blast of air from the lungs. It has been shown that men and dogs can stand terrific rates of decompression without lung damage but they are then exposed to the danger of bends. Fortunately, there is usually a short delay before the onset of unbearable pain and this delay permits descent to lower altitudes.

The danger of bends in planes without pressure cabins can be

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[1] Chairman of Committee on Aviation Medicine, Division of Medical Sciences, National Research Council.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed jointly by the Aviation, Applied Mechanics, and Management Divisions, and the Biomechanics Committee of the Aviation Division and presented at the Annual Meeting, New York, N. Y., November 26–29, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

greatly reduced if the pilot breathes pure oxygen for 1 or 2 hr before an altitude flight. This breathing of pure oxygen exposes the nitrogen in the blood to a lung atmosphere that contains no nitrogen and a large part of the gas is thus washed out of the body before the ascent.

In the case of emergency, bail-outs from planes at speeds over 500 mph are extremely hazardous. There is the danger of striking the tail fin, but the chief limiting factor is the ram effect of the air at these terrific speeds. When the face is exposed to such a blast the air gets under the eyelids, the face is so distorted that the corners of the mouth may be ripped. At very high speeds an arm might be torn from the body. Even if a man is mechanically ejected in his seat or cockpit he encounters severe g forces in deceleration. If they are in the right direction he can survive, but high g forces applied toward the head may cause serious injury.

PROBLEM OF OXYGEN SUPPLY

The problem of oxygen supply is not difficult in a pressurized cabin if it is strong enough to maintain a pressure corresponding to the altitude of 10,000 ft. In the daytime there is no need of an oxygen mask at this level except as a stand-by in case of cabin failure. At night, however, oxygen should be used for all pressures corresponding to levels above 5000 ft because the retina is so extremely sensitive to lack of oxygen that night vision is impaired long before any other function. Most cabins are not strong enough to maintain the 10,000-ft pressure, and above this level oxygen masks should be worn constantly. Bail-outs at altitudes over 25,000 to 30,000 ft are hazardous unless the pilot wears a mask connected with a small oxygen flask. At 35,000 ft men who suddenly stop breathing oxygen retain consciousness on an average 73 sec, some only 40 or 50 sec.

At one time we believed that no one, not in a pressure cabin or pressure suit, could survive an altitude above 40,000 ft. At this height the total barometric pressure is 141 mm Hg in the outer air and in the lungs. The air in the lungs is always saturated with water vapor and this uses up 37 mm of the pressure. We believed that the carbon dioxide in the lungs always accounted for another 40 mm pressure. Only 64 mm was left for the oxygen when the man was breathing 100 per cent oxygen. It was calculated that such a tension provided insufficient saturation of the blood. For most healthy men anything below 75 per cent saturation is approaching the danger limit, and at 65 per cent collapse is imminent.

In practice, however, experimenters in decompression chambers exceeded levels corresponding to 45,000 ft because they hyperventilated, reduced the CO_2 in the lungs and left more room for the pure oxygen. In the last 2 years pressure masks (3) have been developed which raise the pressure in the lungs an amount equal to 4 to 12 in. of water (10 to 30 mm Hg). Using pressures of 10 to 12 in. and pure oxygen, the ceiling for trained men has been raised to 50,000 ft and in some instances a few thousand feet higher. This is useful in an emergency but causes fatigue. A pressure vest, however, relieves fatigue to a considerable extent. We seem to have approached a limit at about 50,000 ft unless the aviator uses a pressure cabin or complete pressure suit with its helmet and clumsy joints. Pressure suits are extremely awkward and do not seem practical.

The very high-speed planes of the future involve so much friction, ram effect, and solar radiation that in spite of the cold stratosphere the cabin temperature may rise to dangerous levels. The limit of tolerance for the human body depends partly upon dry-bulb temperature but chiefly upon water-vapor content, and these depend upon speed and altitude. The A.A.F. Aeromedical Laboratory has expressed the limits of tolerance in a graph which indicates the time limits under varying conditions. Approaching these limits, the pilot becomes inefficient; if he exceeds them he collapses.

EFFECTS OF HEAT AND COLD ON HUMAN BODY

We have a great deal of information about the limits of human tolerance for heat and cold at sea levels. In the case of heat, a man can stay for short periods in a high dry-bulb temperature, perhaps 200 F (93 C) if the humidity is very low. All the heat produced in the body and heat transferred into the body by radiation and convection must then be lost by evaporation. The body can produce 6 to 12 kg of sweat a day and this can account for the loss of 3500 to 7000 cal a day if it vaporizes from the surface and does not drip. With increasing humidity there is a sharp fall in tolerance. The body of a man in all temperatures above that of the skin, about 93 F (34 C), corresponds to a wet-bulb thermometer. At 92 F (33 C) wet bulb, a well-conditioned man can work moderately hard without great fatigue. At 94 F (34.5 C) or higher wet bulb, he can last only an hour or so (4). A few degrees above this point he cannot lose any heat and it is all stored in his body until he develops fever that is eventually fatal.

Since the ability to lose heat in hot climates depends upon the ability to sweat profusely the water supply becomes the limiting factor. A man's body does consist of 70 per cent water but only a small portion of this can be used in an emergency. If in the desert or jungle the body weight drops 5 to 10 per cent as a result of sweating, some threatening symptoms make their appearance. By the time 11 to 20 per cent is lost the man is in danger of heat stroke which is fatal if not treated promptly. Salt as well as water is lost in the sweat and the symptoms of salt deprivation may be serious. It has been found that men who are very well conditioned to heat can get along with surprisingly small amounts of salt but there is no significant adaptation to water loss and not even thirst is an adequate guide to the large amounts of fluid needed.

The limits of tolerance to cold are not so well defined and depend to a large extent upon activity. Recently the group of scientists studying this problem have employed the new "clo" unit to represent the amount of protection against heat loss given by clothing. One clo is the equivalent of the ordinary indoor clothing worn by most people in cool weather. It is sufficient to keep a man comfortable at average room temperature while sitting in a chair. The amount of heat produced under these conditions is called 1 "met."

It is difficult if not impossible to devise a suit for an aviator that has a clo value much greater than 4. If a man is sitting down quietly, therefore producing only 1 met, a 3-clo unit will keep him comfortable and protect his body against loss only at temperatures above 30 F (—1 C). On the other hand, if he is walking and producing 3 met, this suit will protect him at —40 F (—40 C). A man in a sleeping bag in a tent at 10 F (—12 C) needs 8-clo protection, or his body temperature will fall to dangerous levels.

There are many interesting problems presented in the study of heat loss through clothing in cold climates. We do not understand the relationship of the various factors. Water vaporized from the skin condenses in the garments and gives back the heat of vaporization. Some of this returns to the skin but most of it is lost outwardly. After a certain point the garments take up no more moisture. The losses by convection depend upon air movement and temperature differential, and the size of the cylinder represented by the body and its parts. We know very little about the role of radiation in transferring heat through the many layers of garments and not much about radiation from the surface of the garments to the surrounding objects. Heat loss is, of course, proportional to surface which increases as we put on more garments. Convection increases with body movement. Clothing protection has sharp limits. There is only one satisfactory answer for those members of a bomber crew who must remain seated for hours in the extreme cold. They must have electrically heated clothing.

The human body temperature seldom departs far from its normal average of 98.6 F (37 C), $^1/_2$ deg lower in the early morning, $^1/_2$ deg higher in the late afternoon. With severe exercise the body temperature rises 3 to 4 F ($1^1/_2$ to $2^1/_2$ C), and most athletic records are made with what one ordinarily calls fever. If, however, the heat-regulating thermostat in the brain is damaged or the heat load is more than the body can dissipate, the temperature may rise as high as 113 F (45 C) without causing death but this is approximately the limit.

At the other extreme, prolonged exposure in cold weather can drop the body temperature in some cases to 75 F (24 C) without fatal results but this limit is seldom exceeded. Similar levels apparently were reached by the Nazis at Dachau in their horrible experiments with prisoners in water just above freezing. Even exposure to water at 50 F (10 C) for 45 min can cause a fall of 5.5 F (3 C) in body temperature and a state of collapse that is almost fatal.

There is naturally a considerable variation in regard to all of the limits that have been mentioned but the differences between the average healthy man and the prize athlete are not great. Young people are more resistant to bends and to symptoms from lack of oxygen, but youth does not seem to help in preventing black-out. Repeated exposures to bends, anoxia, and black-out are of little aid and may cause loss of tolerance. On the other hand, acclimatization to heat, if only for 1 week, helps enormously. Prolonged residence at high altitudes raises tolerance. There seems also to be an acclimatization to cold but it is not nearly so marked as in the case of heat.

EFFICIENCY OF MEN AND MACHINES

Perhaps we are wrong in trying to place a sharp limit on the factors of safety and devote so much attention to the fatal level. It may be useful to know the fatal level, but the engineer should concentrate on the levels when men first become inefficient. If a certain machine, such as an airplane, is under the control of a man, its efficiency corresponds with that of the man. If in a sharp turn a pilot loses his vision, both man and machine are blind. If the pilot at an altitude of 38,000 ft develops intolerable bends, he and the plane must descend to a much lower altitude. At extremely high or low temperatures there is marked loss of mental capacity as well as loss of muscular power and control. If the pilot does not use oxygen at 18,000 ft he loses judgment and often acts like a drunken man.

Probably the most frequent cause of lack of efficiency is fatigue. For example, the seats of fighter planes were notoriously uncomfortable because the pilot had to sit on a pack made up of life raft, CO_2 bottles, water cans, and similar hard objects. The matter was not serious until droppable gas tanks were added and the fighters sent on long missions. Then seats became intolerable and often were limiting factors in endurance.

This matter of fatigue is of prime importance but surprisingly difficult to measure. The psychological tests are disappointing because reserves of energy are called upon at different rates by different stimuli. It is doubtful if laboratory methods will add much to what we know from experience, and it may remain impossible to give any sharp limits for fatigue.

Fatigue, discomfort, complicated systems of instruments and controls lead to pilot error, and pilot error is responsible for more than half the crashes in airplanes. In all crashes except those which completely demolish the plane, life or death depends upon the factors of safety in the human body. Experience has shown that survival is possible with terrific impacts if the body is given a reasonable degree of protection.

The rate of deceleration, commonly translated into terms of g, depends upon speed at the time of impact and stopping distance—especially stopping distance. For example, if a man falls backward and strikes his head on a concrete floor he may fracture his skull and die. If, however, his head strikes a carpet his injury will probably be slight. When a circus performer drops from a great height and lands in a net he seems to enjoy the experience. Hugh De Haven (5) has recorded cases of survival with slight injury after jumps from 55 to 144 ft where the women have landed on their backs and have been decelerated by 6 in. of soft earth or by a broad copper ventilating duct. It is difficult to obtain exact figures from accidents in aircraft, but there is a well-founded belief that pilots with seat belts and shoulder harness can stand impacts of 40 g and probably much more. It is estimated that men sitting with their backs against a strong bulkhead can stand 20 to 30 g, lying with feet against the bulkhead 25 to 35 g, lying with head toward the bulkhead only 10 g. This makes us wonder why we sleep in Pullmans with our heads toward the engine.

It is noteworthy that head injuries in crashes are responsible for the vast majority of deaths (6). Too often on impact the seat or belt breaks and the pilot's head strikes the instrument panel. Even if the belt holds and there is no shoulder harness, his body may jackknife forward and allow his head or face to hit the instrument board with its sharp edges, knobs, and spikes. The bones of the face, forehead, and temples are thin and delicate. The cranial vault is arched and relatively strong but it does not take much localized force to cause a fracture. The neck and spinal column are surprisingly strong. The shoulders and abdomen are also strong and injuries from belts and shoulder harness are rare. The legs and ankles are fairly strong but they are driven into an ankle trap that would break anything not made of steel.

Fortunately, it is not difficult to make cockpits comparatively safe for all crashes except those that lead to complete demolition of the plane. The engineer does not need to place sharp edges, knobs, and spiked toggle switches in a place where they will be struck by the forehead. He can make a clean instrument panel of thin material and leave a space behind it so that it gives under the impact of the cranium. He can avoid making a control wheel with a rigid shaft that breaks the ribs over the heart. He can design rudder pedals that do not function as ankle traps. If a man with proper harness will tolerate 40 g, why not make full use of this tolerance? Why are there so many cockpit structures that collapse completely at 10 to 15 g, so many seats and belts that give way at 8 or 10 g?

The Army and Navy, aware of these dangers, are redesigning their cockpits according to the principles of physiology, psychology, and safety. Several manufacturers of civilian planes are following their example. The future is bright, but at present in every hundred accidents at moderate speeds we are losing many lives that could be saved if cockpits were better designed. The fault lies not in the man but in the cockpit.

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Applying BIOMECHANICS *to* AIRPLANES

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WHEN we speak of biomechanics, we think of applying engineering methods to problems affecting the combination of man and machine in such a way as to supplement, aid, and adapt man's uses of his senses and abilities in the operation of machinery. Since it is not within our power to redesign man, we have to study his capabilities as well as his limitations when we are designing equipment to be used by him. Rather than trying to adapt the man to the machine, the machine should as far as possible be adapted to the man and, in order to do so, it is necessary to have some scientific basis for approaching the problem; that is the objective of the study of biomechanics.

Biomechanics has been practiced consciously or unconsciously probably ever since the first tool was designed, but it has not always been scientifically done. The term "biomechanics" means more than comfortization.

Too often the machine has developed so fast that the necessary modifications to make it safer or easier to handle, for example, have had to be done later.

AIRPLANE COCKPIT PROLIFIC FIELD FOR IMPROVEMENT

This has been the case for the airplane. Some apologists for the airplane like to cite the early difficulties with the development of the automobile, but forget how much better it is to be able to say "get a horse" than "get an ambulance." The airplane is far more complicated. If one considers the development of the cockpit alone of even the present-day airplane, one can see that in spite of all the thought and care that has already been expended in its design, still every part of it could be subjected to a very critical review. It has been built up in a series of compromises. Switches, instruments, control handles and levers, and the like, were added just as the need grew. From time to time, attempts were made to organize groupings or co-ordinate functions, but more often than not, equipment was located just wherever room could be found.

A study of the cockpit should be fundamental in its approach, before any thought is given to standardization. Such a study should first be made without regard to existing designs, arrangement, or standardization demands. For example, if one started at the focal point of cockpit design, one would carefully determine the reach of a man's arms and legs in the most likely directions for different seated positions and for different bends of the elbow and the knee. In addition to these data, information should be obtained on the magnitude of the grip or force the man could exert with his hands or with his feet.

Such a study might disclose a series of areas where:

1 The maximum reach may be obtained.
2 The maximum grip may be obtained.
3 The optimum seating position is located.

These areas could then be further subdivided into ranges of desirability which would be useful in deciding where to place certain types of equipment which require a certain kind of operation.

The development could be further carried out, subsequently, by considering fatigue in combination with reach, grip, and frequency of use.

RELATION OF HUMAN SENSES TO EFFICIENCY IN AIRPLANE OPERATION

Studies could be extended to determine what roles the senses of feel, sight, hearing, taste, and smell play in man's efficiency and reaction under certain conditions. By means of approaching each problem from a fundamental basis, the following could be considered:

Seating. How may the seating be designed to give (*a*) greater comfort, (*b*) more ease in operating controls. In this connection, clothing may be important, for as the pilot moves in his seat to attend to the various controls of the airplane, clothing friction may hamper his actions considerably. Then, too, to what degree are seat softness and the method of providing it desirable; are various parts of the body properly supported to reduce fatigue; what type of seating would minimize the effects of sudden accelerations best?

Much in this direction has already been done by the military services and individual companies. Perhaps only a little more needs to be done to round out the picture and to co-ordinate the data.

Illumination. What type of illumination is needed within the cockpit under various conditions of natural light? The problem of artificial illumination could first be investigated to determine what type, intensity, and duration produce the least fatigue. Certain limits could be set as a result of such an investigation, subject to changes indicated by possible other considerations.

Dial-Indications. Much study has already been given to dial divisions and presentations, i.e., whether circular or vertical presentations are better has often been debated; color divisions have been used; other methods are possible. In the final analysis, all that is usually required is an indication of the limits.

A field that has been relatively little explored is that of making use of quick visual impressions and subsequent length of visual retention. A system which is easily and quickly recognized and easily retained visually would be most desirable, especially where so many instruments have to be used.

Heating and Ventilating. The importance of heating the airplane cockpit or cabin may be gaged when it is realized that outside temperatures of +60 F at take-off may quickly, in a matter of minutes, change to —50 F at 30,000 ft. Since the cockpit or cabin is limited in volume, it is necessary to bring in air from the outside at a desired pressure and temperature to the occupants.

There are many physiological and psychological considera-

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tions in providing proper heating and ventilating, since the purpose of ventilation is to accomplish the following:

1 Supply oxygen.
2 Remove odors, toxic or poisonous substances.
3 Remove body heat, moisture, and heat from other sources.

The general effects of overheating are as follows:

1 Increased heart beat and blood flow.
2 Increased respiration.
3 Increased sweating, with attack of cramps.
4 General lassitude and dizziness.

The proper design of a heating and ventilating system for aircraft must therefore meet a great deal more than mechanical restrictions imposed by general aircraft specifications.

Vibration and Noise. These two items usually are considered together. Either or both seriously affect man's efficiency if he is subjected to them for any great length of time. In an airplane cabin, most of the noise comes from without, so that the transmission of sound must be overcome; so too the transmission of vibration must be reduced.

Careful engineering studies are made to incorporate methods in the design of the airplane cockpit or cabin which are effective. Such construction as is selected must not be too heavy, since weight is an important consideration in airplane design and it must be economical as to cost.

Controls. What can be done to simplify the operation of the airplane? The automobile is gradually approaching a coordination of all controls at the steering wheel which itself is capable of only one rotational motion, while the airplane has a stick or wheel which is subjected to two motions actuated by the hands and arms, and a rudder control system actuated by the feet and legs. While it may be both impossible and undesirable for control reasons to reduce the number of motions of the airplane control system, yet much could be done toward its simplification.

There are also many switches, levers, and the like, which could be carefully studied to determine:

1 Best means of actuation.
2 Location.
3 Reliability and foolproofness.
4 Simplicity.
5 Means of reducing their number.

Vision. Both the range of vision and means provided for obtaining vision are under constant scrutiny; for full awareness of one's position in taking-off, flying, and landing is important for safety's sake. However, it may be considered an absurdity to house the pilot in a cockpit almost entirely enclosed by shatterproof glass if such a design gives him a sense of insecurity. The type of material used for vision panels and their placement is important, because refraction and reflection may seriously affect the usefulness of such vision panels.

Hearing. What use can be made of warning signals? At what level may noise be tolerated for any length of time without affecting the reliability of the pilot or the comfort of the passengers? What are the long-time effects that excessive noise may have upon hearing?

Psychological Factors. There are certain intangible factors which affect airplane design, and such factors are usually psychological ones. Proper interior decoration may overcome claustrophobia. Arbitrarily increasing the cabin wall thickness beyond that required for the actual structure may help to instill a feeling of security in the passenger.

CONCLUSION

Wherever it is necessary to consider the human occupant when designing a part of the airplane, the subject of biomechanics has its place. The best solution of many of these problems concerning the man in relation to the machine requires the co-operation of the psychologist, the physiologist, and the engineer. The engineer knows the limitations of materials and design; he needs to know the limitations of man. Here is where the medical profession can help him.

Prospective Use of Fusion-Welded Locomotive Boilers

(*Continued from page 624*)

thereunder are specific in the requirement that the railroad company will be held responsible for the safety of locomotive boilers used or permitted to be used on its line and there is no provision that would permit transfer of any of this responsibility.

The procedure to be followed by any railroad that desires to use a welded locomotive boiler or boilers is to file an application for consent for use accompanied by drawings or prints of the particular boiler or boilers involved, showing the design and details of the proposed construction and forms and dimensions of shell joints, and a specification showing the practices proposed to be followed in application, examination, testing, stress-relieving, tests of the completed structure, and the material to be used.

All the A.S.M.E. Code provisions applicable to welded joints in steam-boiler drums or shells and tests and inspections required by this code should be incorporated in the specification. Our insistence on *full* compliance with all the applicable provisions of the A.S.M.E. Code in the matter of welding in the construction of steam boilers is predicated on the fact that this is the only code covering such welding that has been accepted by practically all state and municipal authorities.

To avoid the later occurrence of inquiries in the matter of welding in or on the boiler shell that is not to be radiographed and stress-relieved at the time of construction, such as attachment of flexible stay-bolt sleeves or caps, and the joining of the back head to the door sheet at the fire-door hole, the specification should contain an item to the effect that application of fusion welding in construction to parts and at locations not specifically referred to in the specification, and application of fusion welding in making repairs to any part of the boiler subsequent to the final stress-relief by the builder will conform to established practices in the making of repairs to locomotive boilers of conventional construction. No cracks are to be welded.

Inclusion in the specification or drawings of changes in the well-recognized requirements for construction and testing of welded boilers, such as may in some instances be desired to facilitate construction, omission of the requirement that only qualified welders shall be employed on the work, short cutting or curtailing any of the existing generally recognized requirements which have stood the test of time and use, or the inclusion of designs that have in instances proved of doubtful value, or of untried designs of parts or forms of joints, any of which would be liable to reduce the degree of safety now prevalent, cannot consistently be agreed to. Changes of these kinds will necessarily have to pass through a trial period in *other* steam-boiler service of sufficient duration to definitely determine their prospective continuous integrity.

It should be further noted that though many of the railroad shops are equipped to build riveted boilers, none is properly equipped to perform all the operations required on welded boilers, such as radiographing the welded joints and stress-relieving the structure.

Principles Involved in PROSTHETIC DEVICES

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A HIGH degree of public interest at the present time is directed toward the improvement in artificial limbs. When one views the tremendous advances that engineering has brought about in means for destruction, it is only natural to suppose that the same talent, if applied to the problems of compensating for the human damage that has been done, can make equally great advances.

It is fundamental in approaching the problem of amputation prosthesis to realize that our arms and legs are divinely contrived and not man-made, and that no artificial limb, however cleverly designed and fashioned, will completely replace its flesh-and-blood original. Realizing this, we must bend our efforts toward providing the amputee with an artificial limb that will best serve his functional and esthetic requirements and bring about early economic and social adjustment to his handicap.

This is not a simple task. It involves highly individualized treatment of each patient, from the amputation itself, through the preparation of the stump for the prosthesis, the fashioning of the artificial limb best suited to the needs of the patient, its proper fitting, to the training of the patient in its use and the various physical and psychological procedures necessary for complete rehabilitation.

CASE HISTORIES OF AMPUTEES

Let us briefly review the histories of three patients: A diminutive grandmother had been suffering from diabetes for many years before gangrene set in. She had clung tenaciously to the slim hope that it would not be necessary to resort to surgery, although she realized that eventually it would have to be done. The pain finally became so intense that she begged to have the offending extremity removed, and after the operation she was happy in her freedom from pain and the realization that soon she would again be able to go back to her housework. That was important because she could not afford the luxury of a maid much longer. Neither could she afford an expensive prosthesis.

Fortunately, her stump healed quickly in spite of her age and physical condition, and the surgeon had been able to choose the best location or so-called site of election for the amputation in her case, which was 12 in. below the hip. Her stump was well formed with a fine nonadherent and painless scar and of sufficient length to facilitate the application of an artificial limb. This is not always the case in battle casualties when the amputation must often be performed in the field, and often as a lifesaving measure. There was only one thing wrong with her stump and that was its weakness and poor muscular control. She hadn't been very active in the preceding 10 years because of the circulatory disturbance in her legs and the muscles consequently had wasted. From the standpoint of her prosthesis, her problem was relatively simple. Her functional requirements were minimal. She wanted only to get about to do her housework and possibly on a nice day to go to the corner store to shop. Her esthetic requirements were not great either. It wasn't necessary to fashion a beautiful symmetrical substitute, as was the case in a high-school girl, but she did insist upon a reasonable facsimile because she was a lady, and quite proud, too. But what about the engineering features, from the standpoint of stresses, strains, and torques? How sturdy and durable need her prosthesis be? Her prosthesis need only support 95 lb for perhaps 60 min a day, and her steps would be slow, guarded, and almost exclusively on a flat surface. What, then, would be the best prosthesis for her? The answer was one that would be simple, light, comfortable, and would permit her to do her housework and occasionally shop at the corner store.

A husky factory worker, 40 years of age, weighing well over 200 lb, lost his leg as a result of an industrial accident. His stump was strong and tough and of the length considered ideal in a below-the-knee amputation, and there was no involvement of the knee joint. Yet, in spite of this, he simply refused to wear his prosthesis. It was easy in his case to fit the artificial limb to the stump, but extremely difficult to fit it to the man, and it was only after he became convinced that he would be able to return to his job at the factory, as thousands of others more seriously handicapped than he had been able to do, that he finally showed the necessary willingness to learn how to use his prosthesis. His esthetic requirements were simple, as is the case of most male leg amputees, because the trousers and shoe effectively hide the fact of amputation. His functional requirements, however, were great. His artificial leg had to be well fitted, comfortable, and sufficiently strong and durable to permit him to stand and walk for hours at a time, often on uneven surfaces, and carrying a heavy load.

The third patient was a young marine whose arms were left behind at Iwo Jima. When he finally came to on board the hospital ship, he realized the extent of his injuries but was thankful to be alive. He wondered how his family would react, and his girl friend. He also wondered about himself. What does an artificial arm look like? What will it do? Would he be able to use it to take care of himself, eat, drive a car, get married? Would people stare at him and regard him as a cripple? Would he be able to go back to school and finish his education? There were many difficulties encountered in his readjustment to his disability, and afterward to his prosthesis. He remarked, "My Gawd, do I have to wear that awful thing?" when he first saw the standard hook prosthesis. It took time, patience, perseverance, and an understanding of the man and his problems. His right arm was amputated between the elbow and the shoulder, and he had excellent control of the stump in all directions. Unfortunately, however, there was no stump on the left because it has been necessary to disarticu-

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Note: The opinions and assertions contained herein are those of the authors, and are not to be construed as official or reflecting those of the Navy Department or the Naval Service at large.

late the arm at the shoulder. The application of an artificial arm to the left side was therefore very difficult, and the usefulness of such a prosthesis is very limited. The satisfaction of the functional requirements in a case such as this depends upon the patient's combined utilization of both arms. It was necessary to provide him with artificial arms which he could learn to use with sufficient skill to lead a normal life.

ARTIFICIAL LIMBS MUST SUIT THE PATIENT

These patients represent only a few of the hundreds of different problems which confront the limb surgeon, limb engineer, and limb maker in their attempt to provide the amputee with the best artificial limb for him. They do serve to emphasize the necessity of considering the individual patient, his motivation, and his requirements, both physical and psychological, in relation to his prosthesis.

A well-known research engineer recently remarked during a discussion of artificial limbs, "Draw me up a set of specifications and I will build it for you." What general specifications could be written which would serve both the needs of the grandmother and the husky factory worker, or the marine's right and left arms? These case histories do, however, suggest the need for the engineer to leave his laboratory and drafting board and go to the hospital and the patient, for it is only by the combined efforts of the doctor, engineer, and limb maker that we can expect to solve the multiple problems involved in each individual amputee. Even the commonest prosthesis of all, the denture, requires the closest co-operation between the dentist, the patient, and the prosthetic technician; and, notwithstanding the thousands of dentures in use, no two are alike and none is the product of general specifications. In approaching the problem of amputation prosthesis together therefore it is just as necessary for the engineer to have a basic knowledge of anatomy and physiology as it is for the doctor to know something of the mechanical principles involved.

MECHANICAL PRINCIPLES INVOLVED

In a consideration of the mechanical principles of amputation prosthesis, we must first of all differentiate between the upper and lower extremities. The functions of the latter, having to do mainly with locomotion and weight-bearing, are comparatively easy to restore. But when we consider the delicate and intricate design of the upper extremity with its refined co-ordination of muscle and nerve, and its tactile sensibility, its limitless combination of motions and capabilities beyond comprehension, and its marvels of mechanism, one is not surprised that its imitation or reproduction has defied the efforts of man for centuries. Even the simplest acts, such as putting the hand in the pocket, require tactile and prehensile functions which no inanimate limb could possess. Artists and poets have attempted to depict the symbolism and beauty of the human hand. In Goethe's memorable poem immortalizing the artificial hand, Martin was offended because Godfrey extended his left hand, and said, "Why do you offer me the left hand? Am I not worthy of a Knight's courtesy?" and Godfrey answered, "Were you the Emperor himself, you must be content with this. My right, tho' not useless in war, is insensible to the pressure of love." The young marine used to sit in the theater and hold hands with his girl. It was an effective way of conveying his feelings for her. Can any artificial hand, however accurately its appearance and mechanical features may imitate the normal, be expected to be a completely satisfactory substitute?

MATERIALS USED FOR PROSTHESIS

Regardless of the type of amputee, it is necessary to consider the requirements of the patient from the standpoint of materials used in the manufacture of the prosthesis. In the case of the grandmother, lightness was an essential requirement, even at the expense of strength and durability; in the case of the husky factory worker, strength and durability were the fundamental requirements, and the weight necessary to insure these factors could be tolerated. The prosthesis made for the young marine whose left arm was removed at the shoulder had to be light in spite of all other considerations.

There are four materials generally used in the manufacture of artificial limbs, i.e., wood, fiber, metal, and plastics. Each has its advantages and disadvantages, its indications and contraindications. They have all been successfully applied in many cases.

Wood was probably the first material used in artificial limbs. Willow wood seems to be the most popular, although basswood and other woods have been used. Among the advantages of wood are its durability and the fact that it can be carved and altered to fit the changing stump and the requirements of the amputee. On the other hand, the wooden prosthesis is difficult and tedious to manufacture and requires craftsmanship of the highest order.

Modern metal limbs made of aluminum alloys have the advantage of lightweight with strength, but have the disadvantage of being conductors of heat and cold, and a tendency to become noisy. Fiber limbs are strong and durable but do not lend themselves readily to alterations of alignment in fitting.

Plastics offer probably the most fertile field for research in the development of an ideal material for artificial limbs. Sufficient success has already been achieved in their use to warrant a high degree of optimism. Plastics approach the ideal material in lightness, strength, and durability. They can be bonded to both wood and metal and are easily and quickly manufactured.

The metal from which the joints are made is equally of interest to the engineer. In a hip joint, for instance, use of a ball-bearing hinge is rather standard practice. The metal must be sufficiently malleable, however, to permit bending in different planes to conform to the shape of the patient and the alignment of the limb. Such a metal is not likely to meet the engineering specifications for a ball-bearing race. Theoretically, it would probably seem that the free motion of a ball-bearing joint would be desirable in the knee hinge, but, practically, the ball bearings are being removed in several amputation centers and a friction-ring bearing substituted.

Regardless of the materials used, however, if the patient will not or cannot use his prosthesis, or if it does not suit his needs, it is of little use to him. A young amputee was recently observed sitting on a bench at a roadside inn, apparently enjoying the company of a group of friends. He was wearing an ancient model of wooden peg leg which he was swinging back and forth as the conversation progressed. The combination of the young recent amputee and an ancient peg leg seemed a bit anomalous, so he was asked if he did not own a 1946 model. He waved his peg leg in the air as if to demonstrate and said, "Sure I've got a modern leg and a good one too, but I use this for hunting and fishing and going through the woods and fields. It's light and comfortable, like an old shoe, and, as you see, I don't care about the looks." The wooden peg leg dates back to 500 B.C., but this modern young man chose it because it best served his particular needs.

AMPUTEE LIKELY TO ALTER LIMB TO SUIT NEEDS

The great variety of mechanisms used successfully in artificial legs is not always indicative of the ingenuity of the limb engineer or limb maker. It is often the case that the individual amputee will adjust himself to his prosthesis and alter the mechanism to suit his needs.

(*Continued on page 636*)

Problems in Design of PROSTHETIC DEVICES

By EUGENE F. MURPHY[1]

STAFF ENGINEER, COMMITTEE ON PROSTHETIC DEVICES. JUNIOR A.S.M.E.

It is encouraging to note that mechanical engineers have become interested in the application of engineering to the human body. Engineering has frequently been defined as the application of the forces and materials of nature to the benefit of mankind. Truly the direct application of such forces and materials to so worthy a cause as the improvement of the situation of handicapped people is within the definition.

SOME OF THE PROBLEMS TO BE SOLVED

This paper, prepared with the advice of Dr. Klopsteg, chairman, and Dr. Martin, executive secretary of the Committee on Prosthetic Devices, is an informal presentation of problems rather than of answers. Perhaps in a year or two the answers may be available. Meanwhile, we hope that the interest of many competent engineers may be aroused to help us to solve the more pressing problems, which may be summarized as follows:

(*a*) *Mechanisms*. Knee, ankle, hand, wrist, and elbow joints; of these the knee and hand problems are most formidable.

(*b*) *Materials of High Strength and Lightweight*. Wood has long been used; duralumin is widely employed; laminated plastics have been used recently and are being evaluated.

(*c*) *Fabrication*. The choice of material is obviously dependent upon the tools, equipment, and skills required for fabrication, particularly of those parts requiring adjustment to the individual patient.

(*d*) *Basic Research*. Fundamental information is needed on motions of joints, forces encountered in walking and working, statistical distribution of sizes of body parts, and forces and motions most often employed in daily life.

(*e*) *Fitting Procedures*. Development of the best possible fitting procedures and of methods for describing and teaching these procedures.

The most important points to consider in the design of any prosthetic device are in proper balance, weight, function, and appearance. Clearly an excessive development of one point at the expense of the others will defeat the entire purpose. For example, a hand permitting all the individual movements corresponding to the natural joints would be so heavy that no one would wear it.

CONVENTIONAL LIMBS

A brief description of the structure and operation of a few conventional prostheses may be useful. More detailed information and descriptions of alternate forms may be found in standard works in English, such as Little (1),[2] Florent Martin (2), or the recent work by Thomas and Haddan (3). Several German works, (4 5, 6), some monumental, are exceptionally detailed, including anatomy, care of stumps, fitting procedures, training methods, and long dissertations on mechanical features of limbs, illustrated by photographs and detail drawings. A Spanish book (7) provides the most recent international review.

Above-Knee Leg. Essentially a prosthesis for a thigh amputation is a column from the tuberosity of the ischium or bottom of the pelvis down to the artificial foot molded to fit the normal shoe. The wearer in effect sits on the flaring top of the stump socket, as on a bicycle seat, and ordinarily there is no pressure on the sensitive end of the stump. The ankle joint is essentially a bolt which permits small dorsal (upward) and larger plantar (downward) flexion against rubber bumpers. Scores of designs have been tried, including ball-and-socket or cruciform joints to give lateral motion, tendons in tension as well as bumpers in compression, and cantilever springs or inflated or solid rubber feet to replace either toe or ankle joints or both.

The knee joint is usually a simple bolt placed well back of the center line of the leg. Back checks prevent bending backward, but "jackknifing," or bending forward and collapsing, is prevented only because the resultant force on the leg during weight-carrying will pass ahead of the knee bolt and thus exert a moment favoring extension. Various makers provide rollers and elastic straps to help extend the knee during walking. A simple, light, thoroughly reliable knee capable of bearing weight in any flexed position would be a great aid. Again, many variations in knee joints and many ingenious locks and brakes are shown in patents and the literature.

Below-Knee Leg. Because the normal knee joint and some, at least, of the muscles are present in the case of amputations below the knee, the knee joint need not maintain extension. Because of gliding of the knee, however, this joint also lies behind the center line of the thigh. The shank portion ends in a socket that supports body weight at the bony prominences of the tibia, and jointed metal bars extend upward on each side to a leather corset, or lacer, surrounding the thigh. These bars support the limb while it is off the ground and, in many cases, permit some of the weight to be carried on the conical corset or even on an upper edge of the corset at the ischium. Again, no weight is carried on the end of the stump. The joints are frequently of the ball-bearing type; a bolt passing through the prosthesis is clearly impossible because of the presence of the knee. Breakage is frequently due to failure of these joints or of the fastenings between the bars and the shank. Proper fitting is exceptionally important.

Conventional Attachment. Attachment to the body ordinarily requires a pelvic belt or suspenders. Frequently straps to the knee control are attached to the suspenders or pelvic band.

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[1] Evanston, Ill. On leave from University of California, Berkeley, Calif.

Contributed by the Aviation, Applied Mechanics, and Management Divisions, and the Biomechanics Committee of the Aviation Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

For best control, especially with short above-knee stumps, joined metal bars must be carefully fitted between the leg and the pelvic band.

Suction Socket. Since the leg weighs only a few pounds and the stump has a large cross-sectional area, it seems reasonable that atmospheric pressure might be used. Indeed, a patent on this idea was granted to Parmelee (8) in 1863. The obvious immediate objection would be the perspiration and possible damage to the skin, and apparently the method was dropped. In recent years, however, in England and especially in Germany, the suction socket, worn on the bare stump, has been widely used. It is estimated that there are at least 10,000 such sockets in Germany, where it became the standard socket for the above-knee prosthesis during the recent war. Perspiration is at first objectionable, but it soon diminishes. There are no skin troubles, and the prosthesis feels as if it were an integral part of the leg, according to the wearers. Simplicity, direct control, and speed of attachment are leading advantages. The stump becomes more powerful instead of atrophying.

Skeletal Attachment. Another idea that has been proposed is the direct attachment of the prosthesis to the bone. The biggest objection to this is the possibility of infection or inflammation where the foreign body protrudes through the skin. Experience with fracture plates and with external fixation and experiments on eighteen dogs by Dr. James Blodgett of Harvard Medical School indicate that these complications may not arise with proper operating technique. One difficulty is that Vitallium, the most suitable material, cannot be machined, but must be cast precisely.

Arms. When the normal elbow remains, the arm is merely a framework for carrying the hand. Leather corsets surrounding the forearm and upper arm are reinforced by metal side bars with joints opposite the elbow. A harness keeps the arm in place.

When the amputation is above the elbow, a more complete structure of wood or light metal is used. Usually a ratchet is provided to lock the elbow in any of a variety of positions, and a cord from the forearm passes over pulleys on the upper arm and shoulder to an anchor on the harness, so that forward movement of the upper-arm stump will tighten the cord and flex the elbow. The ratchet may be released by operation of a knob with the other hand, or in some designs by a slight tension in the cord, just as one releases a window shade.

Hands. No matter how elaborate, a mechanical hand will always be a poor substitute for the human hand. The loss of the sense of touch is especially serious. Martin (2) mentions some experiments by an Italian on the provision of rubber bladders in the finger tips, communicating with rubber bags pressed against the thorax, to convey a substitute sense of touch. The prehensile or vise action between the opposed thumb and fingers can be replaced to a limited extent, ordinarily by making the thumb approach the space between the first and second fingers. It is quite possible to grip, in this way, a pencil, fork, or glass, and to support a substantial load, such as a briefcase, on hooks formed by the permanently bent fourth and fifth fingers. A mechanical hand capable of these operations at present weighs about 1 lb, a burden that is endurable with a forearm amputation, but which represents a severe load on a short upper-arm stump, due to the considerable lever arm at which the hand is placed. Unfortunately, many persons who have lost only one arm eventually abandon their prostheses, preferring an empty sleeve to a heavy arm and hand of limited value. The bilateral amputee is in a particularly serious predicament. Thorough training in the use of any prosthesis is essential.

Conventional hands usually move all the fingers simultaneously, although patents and literature describe a variety of attempts at equalization by whiffletrees, cords and pulleys, and other devices to permit closing the fingers about a spherical or irregular object.

Cosmetic gloves of latex or plastic film, colored to resemble the normal hand, are under investigation for possible use over a mechanical hand. Such a glove seems more practical than a tinted plastic surface of the hand itself.

The utility hook, while admittedly undesirable in appearance, permits considerably more function for a tolerable weight than the present mechanical hand. The hook is particularly useful for those engaged in farming, shop work, or manual labor. Usually the joint at the cuff is designed so that a hook, a mechanical hand, and various special appliances suited to the wearer's trade can be readily interchanged. The relative importance of function and appearance depends upon the activities of the individual, but in any case appearance of the hand is more important than that of the leg.

Motion-study engineers have long pointed out that one hand is generally used essentially as a vise, with the other hand performing most of the delicate operations. Therefore the hook or mechanical hand can replace a single hand in most everyday affairs. Motion-study experts could render a distinct service by indicating the specific motions and forces actually required of the hand in washing, dressing, eating, and in selected occupations. A rational basis would then exist for selection of the best compromise between action and weight.

Either the hook or the hand is conventionally operated by a cord attached to the opposite shoulder. The hand may be closed by a spring and opened occasionally by voluntary muscular control, or the action may be reversed. A lock is often provided, usually with a knob for control by the other hand. Pronation and flexion of the wrist, if possible at all, ordinarily require operation by the opposite hand.

In the cineplastic operation, which is a subject for debate in medical circles, skin-lined tunnels are made through one or more remaining arm muscles. Rods extending through these tunnels are attached by cords (or rods) to the artificial hand. Voluntary contraction of the muscle pulls the cord and operates the hand. The chief difficulties seem to be the breakdown of the tunnels and insufficient available energy, or force times displacement of the tunnel. Recent developments in Germany, however, indicate that a pull up to 40 lb and a displacement up to 2$^3/_4$ in. are feasible. The cineplastic tunnel of course should give much greater sensitivity and control than the opposite shoulder. Possibly the tunnels could be used to control auxiliary power supplies. The cineplastic operation is probably best suited to a patient of the "white-collar" group.

The general problems of materials and design for all parts may now be considered.

DESIGN AND CONSTRUCTION CONSIDERATIONS

Strength and Weight. The strength-to-weight ratio includes the problems of both material and appropriate design. There are many important factors to be considered beyond the simple ratio of tensile or compressive strength to specific gravity. The parts must be adequately thick to permit ready and durable fastening to other members. Many of the loads are in compression or in flexure. Many parts are so long that they may be considered subject to column action as well as to direct compression loading. Adequate allowance must be made for possible changes in the thickness of the material during forming and fitting and during actual usage because of wear and corrosion. The designer must decide whether to use the crustacean form, in which the loads are carried by an outer shell of the material, or the skeletal construction of the normal human body.

In any case, it must be remembered that most limbs finally fail at the juncture rather than in the middle of a substantial section, such as the shank, thigh, or arm. This failure at joints may involve either pulling out of rivets or other mechanical connections, the failure of welded, brazed, or cemented joints or breakage of movable joints, such as bushings or ball bearings. Fatigue failures occur at sharp bends or notches. It would be irrational to design a limb which would never fail, even under loads that would fracture the normal limb.

Materials. The conventional material for artificial limbs has long been wood, usually willow, covered with rawhide. This material has the advantage of being easily worked with simple shop tools and reasonable skill on the part of the artisan. Small adjustments can readily be made to suit changes in the stump or to improve the comfort of the patient. The rawhide covering adds considerably to the strength and gives a reasonably pleasant sensation when touched. Usually the limb is painted with a flesh-colored enamel both to improve appearance and to resist penetration by perspiration.

The duralumin limb was developed after Marcel Desoutter in England lost his leg in an airplane accident in 1912. He and his brother, an aeronautical engineer, realized the advantages of a light alloy. This material has been quite widely used both in the sheet or tube form and in cast parts, such as the knee mechanism used in the present Army leg and the palm and back plate of the hand supplied to military amputees. Inherently aluminum requires more elaborate equipment for proper forming and perhaps greater skill on the part of the workman. The various parts can be fastened together by riveting or welding. Failures usually occur at such joints or, occasionally, are due to corrosion caused by perspiration. The hard surface causes wear on clothing, and the sound when the limb is struck is objectionable.

Magnesium has frequently been suggested for artificial limbs, but so far has not been accepted because of the corrosion problem. Perhaps some reader may know a thoroughly adequate treatment to eliminate this difficulty.

In recent years various plastics and laminating materials have been suggested for artificial limbs. Some of the Army temporary legs are made from fiber sheet which is rolled into appropriate form and riveted up the back of the leg. The Navy legs are made by pulling a stockinet over plaster-of-Paris replicas, dipping in a thermosetting plastic, and curing in an oven; or of duck impregnated with plastic. Recently some commercial shank portions have been made by a bag-molding process using a cloth laminate. It has been suggested that some parts, such as knee or hand mechanisms, might be molded from plastic, although probably considerable redesign would be necessary.

It is essential that the material chosen for the stump socket can be formed accurately and quickly with inexpensive tools, and that once formed the socket will not change dimensions in service. The material used must not irritate the skin. It should resist corrosion, rotting, and fungus growth; preferably it should not absorb perspiration. Leather, for example, has often been used, but it is objectionable because it soon becomes offensive from absorption of perspiration. Possibly a suitable method of impregnating the leather might be adopted. Conventionally the socket is carved integrally with the wooden shank or thigh. Plastic laminates have been widely used, and experiments on thermoplastic materials are continuing.

The cost of the small amount of material involved in any limb is not a consideration. The problem is to find the best material from all points of view.

Joints. The types and locations of joints affect durability and comfort. Ordinarily low-friction joints are considered necessary, and there is some debate as to the relative merit of ball bearings, plain bushings, and oilless types of bearings when used under the rather difficult conditions of ordinary service. There is some question as to whether friction would actually be desirable in the knee mechanism, and some inventors provide adjustable brake mechanisms. The amount of friction necessary at the knee seems to depend partially upon the individual preferences and activities of the wearer, which may vary from hour to hour. The brake should therefore be readily adjustable, preferably without the necessity for sitting down or disturbing the clothing.

In the case of ordinary knee joints for below-knee amputations, a simple hinge joint connects with the duralumin or steel bars which link the prosthesis for the shank to the corset or lacer which encloses the thigh. During fitting, it is frequently necessary to bend the bars quite near the bearings. Bends of short radius should be possible without warping or distortion of the joint. It has been suggested that dummy bushings might be provided during the early fitting of the leg and that the final holes might be bored and ball bearings or bushings inserted only after the fitting has taken place. If it is necessary to harden the rubbing parts, it must be possible either to postpone hardening until after fitting or to bend the bar quite close to the hardened portion without undue distortion of the joint.

Power Supply. An interesting suggestion is the provision in prostheses of some source of auxiliary power. Some have been designed in Europe, and there are a few American patents. This auxiliary power would be particularly desirable, of course, to permit forceful operation of an artificial hand or to improve the walking process for a patient with a high thigh amputation or a disarticulation through the hip. Energy sources which have been suggested include airplane-type storage batteries, compressed-gas cylinders, such as those used to recharge soda-water siphons, chemical reactions releasing gas, or various types of springs. Simple thermodynamic calculations show that gas under pressure with simple valves would be used so wastefully that the user could not carry an adequate supply.

It would be desirable, of course, to carry a power source in the pocket, or on a belt, and to provide the motor mechanism close to the torso in order to reduce leverage exerted on the stump. The controls must be simple and should leave the other hand free. Some readers may have valuable data upon the relative weight or methods for control of various sources of energy suited to this work.

Moisture Protection. Another problem is protection against moisture due both to perspiration and to occasional contact with rain, puddles, or the shower bath or tub. Condensation may occur when a wearer enters a house in winter, just as on eye glasses. Moisture causes corrosion, attacks soft materials, softens parts such as felt, and affects bearings. For example, ordinarily it is impossible to wear a prosthesis into the shower or tub. A person with bilateral amputation is therefore at a great disadvantage even though he may be able to perform most of his other daily tasks with the aid of his prostheses. Perhaps some readers, during the war have gained useful experience in the development of moisture-resistant materials or envelopes which might enclose the limb as a whole, or at least the more delicate portions.

Fitting. One of the most important features of a good prosthesis is careful fitting and alignment; these are more valuable than any single mechanism. It is here that persons with long familiarity with the artificial-limb industry can make a great contribution. The socket must fit the stump comfortably, and the joints must be so located that the stump will not rub against the sides of the socket. Methods for describing the fitting process and training prospective fitters are needed. Various "fitting machines" and jigs developed in Europe during the last quarter of a century are being investigated and new procedures adapted to current American problems are being developed.

Standardization. Ordinarily the limb industry has run on essentially a "tailor-made" basis with all parts of each limb produced almost entirely to suit the needs of the individual customer, in relatively small shops usually associated with the fitting room. The work is done by hand or with simple power tools. Due to the pressure of the war, the Army and Navy have set up large amputation centers in which considerable numbers of patients of similar conditions have been gathered. The problem has thus come quite forcibly to public attention, and the possibility for standardization and mass production has been more obvious. It should be pointed out, however, that in peacetime there are ordinarily from two to three times as many amputations per year as there have been in the Armed Services during the entire war. These civilian amputations are usually rather scattered and so do not come to public attention. It is correspondingly difficult to obtain accurate figures on civilian major amputations although estimates run from 25,000 to 40,000 per year due to accident and disease combined. Some have estimated that the most frequent source of hand amputations is the corn-chopping machinery used so extensively during the autumn. Industrial and automobile accidents of course are frequent causes for amputations. UNRRA faces a serious problem in attempting to supply thousands of limbs to amputees in devastated countries abroad.

It is thus apparent that in peace, as well as in war, there is a field for what might be termed "semimass production" of standardized parts to be assembled by skilled fitters into individually tailored limbs. These standard parts might include a limited number of stock sizes and degrees of ruggedness of shins, thighs, forearms, and upper arms, and probably one or two stock sizes of each joint. The length of each portion should be capable of simple adjustment during the fitting procedure. The socket which comes into contact with the patient's stump must, of course, be produced on an individual basis. Frequently, in fact, a number of sockets must be made successively for one patient as the stump shrinks due to atrophy of tissue under the pressure caused by the prosthesis and the lack of use of the original muscles.

The joints, fittings, and screw sizes used in prostheses might well be standardized. Many limbs needlessly require special tools for repairs. The principal wearing parts should permit repair or replacement at the shop of any limb maker, without return of the limb to the original maker.

COMMITTEE ON PROSTHETIC DEVICES

The Committee on Prosthetic Devices was set up by the National Research Council at the request of the Surgeon General of the Army in order to study the fundamental principles which underlie sound design and, through an extensive program of research and development, to prepare specifications for the best available limbs. A parallel Committee on Sensory Devices is developing aids for those whose hearing or vision has been impaired or destroyed in service. Both committees function under the Board for Prosthetic and Sensory Devices of the National Research Council.

The committee does not endorse any commercial limb or assist any commercial company in the further development of an existing proprietary article. It does not attempt to examine purely commercial devices or alleged improvements except as they appear to contribute to fundamental knowledge, although it has a museum of typical prostheses for study by its staff. It possesses a complete file of patents in Class 3, Artificial Body Members, except for the subclass on artificial eyes. These patents are being reviewed as a part of a general study of the literature by its staff and some of its contractors, without any intention to select any particular patent for inclusion in the final specifications. Rights of the Government under any inventions arising from research sponsored by the committee are currently being defined.

Orginally financed by the OSRD, the committee later received support from the Army through the Office of the Surgeon General. Further work will be jointly supported by the Army and the Veterans Administration.

The committee is composed of three orthopedic surgeons and three engineers, all of national reputation, with Dr. Paul E. Klopsteg, director of research of Northwestern Technological Institute, as chairman and Dr. Miles J. Martin as executive secretary. Its offices are at the Northwestern Technological Institute, Evanston, Illinois. It does not operate a laboratory but rather initiates, financially supports, and technically supervises research on fundamental problems or specific devices by means of subcontracts with responsible, competent laboratories. Prospective contractors submit proposals outlining object, methods, qualifications of personnel, apparatus available or needed, and estimated costs.

RESEARCH CONTRACTS

Some of the fundamental knowledge needed has involved the kinematics and dynamics of locomotion. This problem has received surprisingly little attention in an age of ingenious devices and careful stress analysis. Steindler (9) has covered much of the present knowledge. Recklinghausen (10) gives the most mathematical treatment. At present two subcontractors are working on the determination of the forces acting on the leg during walking. Two force plates have been designed and built to measure forces in all three directions and torques about all three axes causing reactions on the foot. Electrical-strain-gage dynamometers are used to measure the very small deformations which take place in the bars supporting the plate. The responses of the gages are recorded on oscillographs. Because this work is only just getting under way, we are unable to report upon its progress.

Another study is currently being made by high-speed x-ray photography of normal and amputated persons. One of the limiting factors here is the allowable exposure to the x-radiation, which must necessarily be unusually intense, so that a given patient can be safely rephotographed only after the lapse of some time.

Yet another study of the kinematics of motion, including the ranges of motion of the joints, using pins inserted into the leg bones, is being undertaken with slow-motion pictures. Both types of photographs are synchronized with the oscillograph records. Myographic studies of the tiny action currents set up in muscles during use are conducted to determine the sequences of operation of muscles during walking by normal and amputated subjects.

A fundamental investigation looking toward standardization of parts has been made through the measurement of a number of portions of the body on over 2800 subjects, including both veterans and a cross section of the general population. This work, under the guidance of a trained anthropologist, is expected to yield statistical data from which a few standard sizes may be chosen satisfactorily. It is recognized, of course, that there will always be a few patients who will require special limbs of unusual sizes.

Specific items under development include better joints for elbow and wrist, including a controlled rotary wrist mechanism; a prosthesis for the cineplastic operation; several approaches to a hand which will combine the utility of the split hook with a satisfactory appearance, including possibilities of auxiliary power; a knee that will bear weight when flexed; suitable methods for the preparation of sockets, especially for the suction socket; the use of plastics in prostheses; new designs especially adapted to plastics; and the development of better ankle mechanisms and feet. Additional work is needed upon the development of better hardware, including the straps and joints used between the parts of prostheses. The first annual report of the committee (11) is available from its headquarters on request.

CONCLUSION

Engineering aid can be given in the following forms:

(*a*) Mechanisms, particularly a load-bearing knee and a better hand.

(*b*) Materials and assemblies which are strong, light, waterproof, and easily formed.

(*c*) Rugged, light, simple methods for fastening.

(*d*) Fundamental knowledge of biomechanics and determination through motion study of the most essential motions and associated forces.

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A Liquid-Propellant Rocket Motor

(*Continued from page 616*)

Since the jet stream is traveling at about 6 times the speed of sound in the adjacent air, the air is unable to compress rapidly enough and in effect forms a "solid" cylindrical tube through which the exhaust gases move. Eventually, friction slows the outer layers of the flame column down and air mixes with it causing the conical taper at the end of the flame.

In closing, we might mention an outstanding adaptation of the liquid-propellant reaction motor to conventional aircraft in order to emphasize the fact that rocket power has progressed from the experimental stage to a practical type of power plant that is now at hand.

The application we have in mind is the use of the liquid-propellant rocket for assisting take-offs of heavily loaded aircraft whose motors are not powerful enough to supply the necessary thrust. This characteristic of the rocket motor is especially useful on water-borne planes and those which operate from airports at high altitudes where air density does not permit proper aspiration of the engines, thereby reducing power output.

Many more applications which will have a profound effect on transportation and communication are in the not too far distant future. Very shortly the liquid-propellant rocket motor will emerge as a full-fledged aircraft power plant. The age of rocket power is here.

Principles Involved in Prosthetic Devices

(*Continued from page 631*)

After becoming adjusted or accustomed to his artificial limb, he will be loath to part with it because it has become a part of him, so to speak. You will find professors of engineering and men who are financially able to buy any type of prosthesis that may be offered, clinging to the limb to which they have become accustomed and on which they know they can depend for reliable service, even though the engineering principles in its mechanism may appear to be basically unsound from a theoretical point of view. There are hundreds of above-the-knee amputees, for instance, who will never change from the shoulder control to the so-called pelvic band or stump-controlled limb.

In the case of the grandmother, it was obvious that her stump was neither able to lift the artificial limb at the start of a step nor exert sufficient backward thrust to extend the knee and prevent buckling as her weight shifted on the limb. The importance of an ideal gait cannot be overemphasized, but when compared with comfort and utility, it decreases in significance. Comfort and utility are inseparable from good alignment and fitting. Above-the-knee amputees will often become accustomed to a certain type of knee mechanism, or ankle joint and foot, or to a definite type of limb bearing.

From a mechanical standpoint, our factory worker should have his knee mechanism so adjusted that he would be able to walk fast and stand for long periods. There are patients, however, who prefer to adjust the ankle instead of the knee for the same purpose, because by dropping the foot, the knee is forced into extension. The motions of the human knee are hard to duplicate, there being not only flexion and extension as in a fixed mechanical joint, but also a gliding action of one bone on the other.

ARM PROSTHESIS MOST DIFFICULT PROBLEM

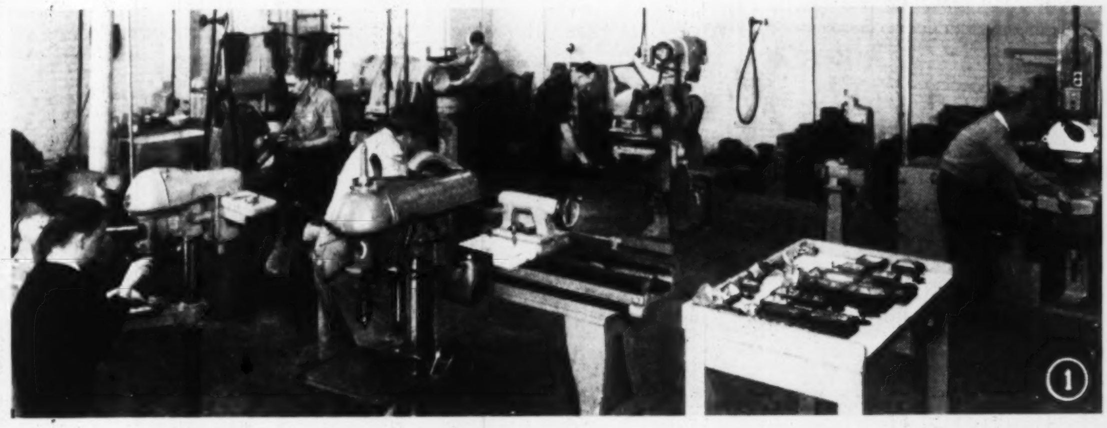
Probably the greatest problem facing the engineer, the surgeon, and the limb maker, is to provide the arm amputee with a satisfactory prosthesis. A case such as that of the young marine is especially difficult because it is necessary not only to provide a prosthesis but a means of activating it. In the standard single-arm amputation, the artificial arm is activated by the shoulder of the opposite side, and with proper training the amputee soon becomes adept in its use, but a good stump is essential. It does seem possible that engineering ingenuity could supplement the patient's muscular power by mechanical means. This might take the form of pneumatic, hydraulic, or even electrical applications. The guiding factors in development of these aids, however, must be minimum weight and maximum simplicity, because the more complicated the mechanism is, the less apt the patient is to use it and to wear it. All too frequently, arm prostheses are relegated to the closet shelf.

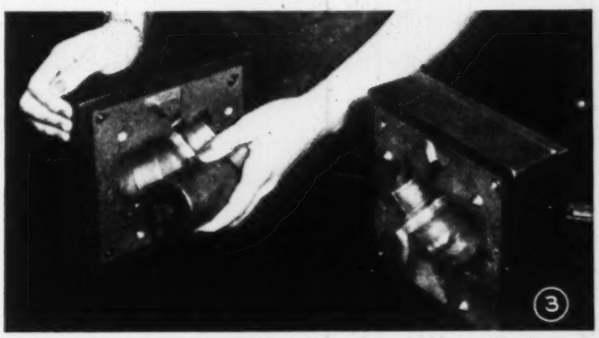
PSYCHOLOGICAL ASPECTS

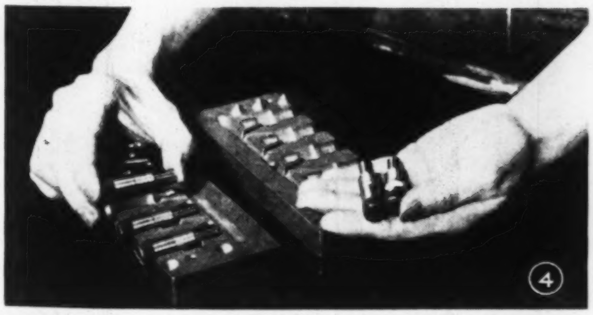
Finally, there is something more important than the artificial limb itself, and that is the attitude of the amputee toward his disability and his prosthesis and the attitude of the public toward him. Unless the amputee has received the proper reassurance and understanding of his problem, and unless he has become properly adjusted to his disability and understands the limitations that are inherent in an artificial limb and that no prosthesis can ever be expected to substitute fully for his normal member, and unless the attitude of the public toward him and his prosthesis is one of understanding and willingness to accept such physically handicapped individuals into the normal social and economic order, no mechanical aid alone can be expected to rehabilitate him.

STEPS *in the* LOST-WAX PROCESS *of* PRECISION CASTING

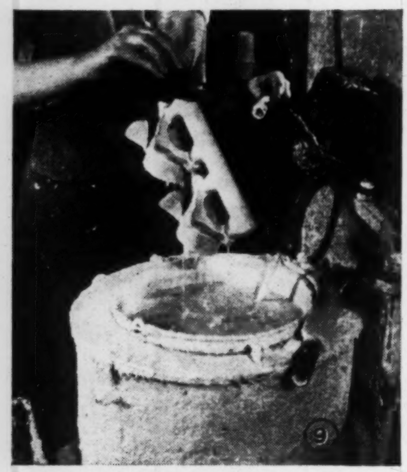
Photographs on This and the Following Pages Illustrate Steps in the Lost-Wax Process of Precision Casting by Haynes Stellite, Kokomo, Ind., described on pages 467-468, Mechanical Engineering, May, 1946



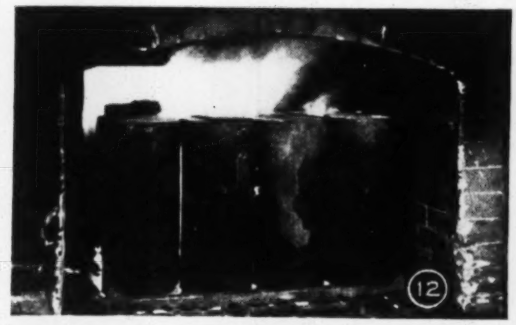




[(1) Over-all view of die shop. Either metal or wood patterns are made slightly oversize to allow for shrinkage. Dies are made of soft metal having a relatively low melting point encased in a steel shell. (2) The pattern is embedded in plaster in the lower shell. The upper shell is set in place and filled with soft metal. Plaster is removed from the lower shell, which is then filled with soft metal. The die is checked against the pattern. (3) Metal cores are used to form the necessary cavities. Cores must be designed for easy removal from the wax form. (4) Internal threads are produced by forming the required thread on the metal core. (5) The die is held in a hydraulically operated clamp. The gun, previously filled with molten wax, is inserted and the plunger rammed home by a hydraulic press.]



[(6) When filled, the dies are removed, opened, and the wax pattern removed from the die. Cores are removed and the wax pattern is delivered to the belt conveyer for assembly. (7) All wax patterns are carefully inspected and checked before assembly to gates and risers. (8) Electric irons are used to attach the pattern to gates and risers also made of wax. A number of patterns may be attached to a single riser. (9) Completed assembly is first dipped in a bath of fine silica suspended in a suitable medium. This insures close contact and a smooth finish. A second and heavier coating is sprayed on. (10) Assembly is waxed to a metal base and surrounded by a metal shell. A paper wrapper is placed around the shell, extending well above it, forming a flask. The shell and wrapper are also waxed to the base. (11) The flask is placed on a vibrating stand and carefully filled with a chemical-hardening investment to the top of wrapper. Vibration insures close contact and release of air bubbles. The flask is then placed on a shaker table where it remains until the investment hardens. The extra head provided by the wrapper furnishes the necessary pressure to insure compactness.]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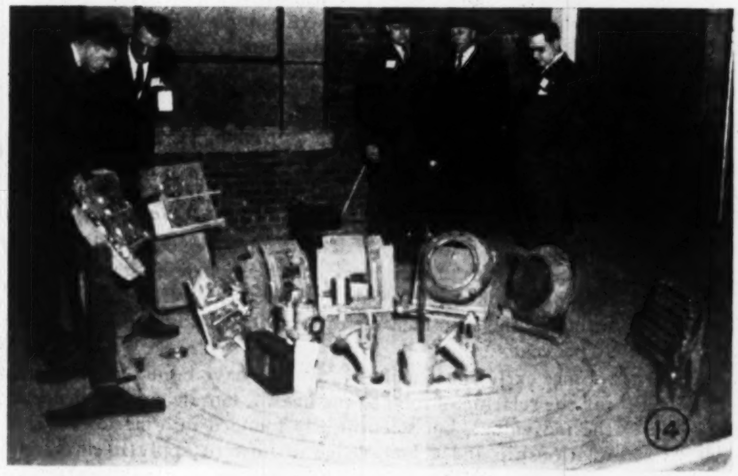
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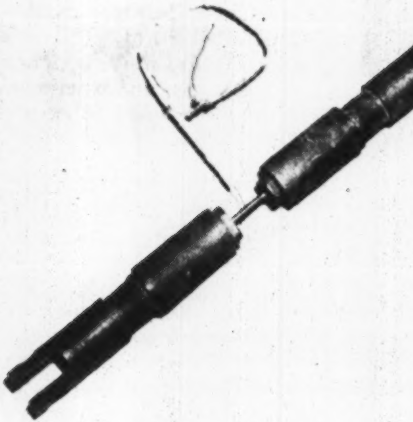
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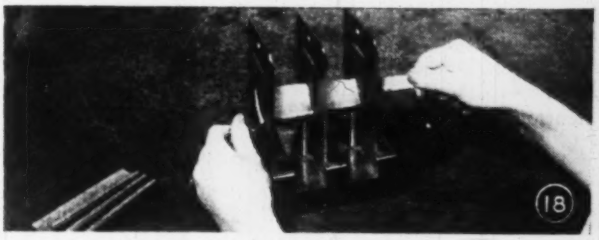
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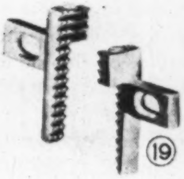
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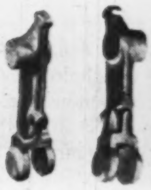
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[(12) The extra head is removed and the shell containing the wax assembly passes through a furnace at a temperature of from 1300 to 1900 F. The wax is burned out. (13) The required weight of metal is melted in an electric furnace. The hot flask is clamped to the furnace which is then inverted. Air pressure on top of the molten metal forces it into all cavities in the mold. Grain size is regulated by controlling the temperature of the metal at the time of pouring. When cold, the investment is broken away from the casting. Gates and risers are removed. (14) Inspection is by x ray or gamma ray. A capsule of radium is attached to a stand at the center of a series of concentric circles. The position of the pieces to be inspected is determined by their relative thickness. This inspection is carried out at night when the building is unoccupied. (15) Films are inspected by trained operators for flaws or indications of gating stresses. (16) All parts that pass a visual inspection are subjected to Zyglo inspection. (17) Because the high temperature at which tensile tests must be made, special draw heads with Stellite ends were developed. The draw heads with the test piece screwed into place are brought up to temperature in an induction furnace. Only the test piece and inner ends of the draw heads are heated. The outer ends that are attached to the testing machine remain cool enough to handle. (18) Many special jigs and gages are used for the wide variety of parts that must be held to close tolerances. (19, 20) The lost wax, or investment process, is especially adaptable to parts that otherwise would require numerous machine operations. The sewing-machine dog and the aerial-camera crank shown are examples of precision casting.]

FOOD SERVICE FOR WORKERS

Résumé of Report to Division of Engineering and Industrial Research, N.R.C.

PRACTICES, health aspects, and recommendations to management and labor regarding the problem of in-plant feeding are set forth in a 120-page report of the Subcommittee on Nutrition, by Dr. Robert S. Goodhart, chairman, Dr. Maurice E. Shils, secretary, Dr. William H. Forbes, and Dr. Andrew C. Ivy, which they made to the Committee on Fatigue in Industry, Division of Engineering and Industrial Research, National Research Council.

For those interested in feeding workers on the job, this report offers many valuable suggestions and methods concerning the task of industrial feeding. Some of the points covered by the report follow:

World War II saw the marked expansion and development of the in-plant feeding of industrial workers as an important aid in the great program of production for victory.

As with other activities which expanded during the war, the question arises: What does the future hold? Is industrial feeding to be a casualty of peace—having served its purpose in war—or is there value in it sufficient to merit its continuation and progress as part of the way of American life? The time is now at hand for a re-examination of our wartime experiences and an evaluation of the role of industrial feeding in peacetime.

In addition to considering this question, the report proposes to indicate and discuss the health basis for industrial feeding and the operational problems to both management and labor.

In-plant feeding involves the large-scale production, merchandising, and distribution of food, and requires interest, knowledge, and planning as much as other industrial production problems. It is complex because of the layout, equipment, and techniques involved in preparing and serving attractive nutritious food at reasonable cost. It yields value in the form of improved employee health and morale in proportion to the attention given to it.

WHY FEED WORKERS ON THE JOB?

Industrial feeding is a health and morale measure, yielding benefits to worker and employer, just as surely and importantly as are good working environment, safety, and industrial medical care.

In a survey made during 1944 it was found that 100 out of 101 plants will definitely continue in-plant feeding after the war. It was concluded that the practicability of on-the-job feeding has been demonstrated to management. "When stripped of its wartime necessity, it still looks good to them as a means of maintaining morale, health, operating efficiency, and employee relations. Many plants consider it as a factor in production." Management was asked to list the advantages and disadvantages of in-plant feeding. The answers proved that the benefits overwhelmingly outweighed the disadvantages.

Examination of many reports on the benefits of in-plant feeding programs reveals that the morale effects of such programs are just as important as the nutritional effects; and, unless special studies are made, it is not possible to differentiate between them. From the practical point of view, it is not necessary to differentiate, since the over-all result is the important thing.

Industrial nutrition involves more than making available good midshift meals. It includes all contributions in the field of nutrition that can profitably be made by industry to the workers' health and productivity.

Several examples will suffice to indicate what is meant by the statement. Heat exhaustion results in large part from insufficient intake of water and salt in hot environments where perspiration is profuse. One steel mill was able to reduce the incidence of heat exhaustion of its workers from more than 300 to less than 25 in a given period by the simple expedient of putting salt as a one tenth per cent solution in the drinking water. During the building of Boulder Dam the intake of additional water and salt similarly played an important role in reducing the incidence of heat exhaustion. Between-meal snacks during rest periods are being made more available in industry. Psychological, physiological, and nutritional factors are undoubtedly involved in stimulating morale and productivity. In a study of the productivity of employees in a shoe factory in New England, it was found that definite improvements in the output of certain types of piecework occurred when mid-morning and mid-afternoon snacks of milk and cake were eaten. In some instances the sustained increase in production was as much as 10 per cent.

Since early times many statements have been made concerning the relation of food to the health, morale, and efficiency of the individual, but scientifically founded information on this relationship and a knowledge of how to apply it effectively have been accumulating only within the past three decades. As a result of this information, a "yardstick" of nutrition has been established whereby, after checking eating habits, intelligent corrective recommendations can be made for improvement where necessary. This yardstick—The Recommended Dietary Allowance of the National Research Council—consists of various food factors recommended to insure optimum health. The figures pertaining to adult men and women which are applicable to industrial workers are given in terms of actual foods and quantities in Table 1.

TABLE 1 SAMPLE DIETARY PATTERN, PREPARED BY FOOD AND NUTRITION BOARD, NATIONAL RESEARCH COUNCIL, TO SHOW WAYS IN WHICH ALLOWANCES MAY BE MET

Milk	1 pint
Egg	1 daily, if possible. (On days not used, beans, peanuts, cheese, or more milk or meat to be used instead)
Meat, fish, or fowl	1 or more servings
Potatoes	1 or more
Vegetables	2 or more servings. One green or yellow
Fruits	2 or more. One citrus fruit or tomato or other good source of vitamin C
Cereals and bread	Whole grains or enriched
Other foods as needed to complete the meals	

The National Research Council's Committee on the Nutrition of Industrial Workers recommends that the midshift meal supply at least one third of the recommended dietary allowances.

As to signs and symptoms of decreased health and efficiency associated with the prolonged eating of diets which are not up to the recommended dietary allowances, evidence indicates that if the diet does not meet the body's needs, undesirable physiological changes begin and, given enough time, such a severe deficiency may develop that incapacity results.

Many dietary surveys have been made on large and small groups of the American population in all parts of this country. These surveys agree on the following points: (1) Consumption of diets below the recommended dietary allowances is widespread; (2) diets generally improve as income increases; but (3) there are many people who eat unbalanced diets despite the fact that they can afford better. Even in the low-income groups better food selection would allow for better nutrition at little extra cost.

The object lessons of these surveys were twofold: (1) The need for making nutritious foods more available, and (2) the need for insuring better selection of foodstuffs.

Industrial feeding is particularly well-suited to contribute significantly toward the achievement of these objectives.

Since industrial workers form such a large segment of the population, the results of the surveys discussed in the report must generally apply to them. Surveys made directly among industrial workers give further proof of the need for improvement in their dietary habits.

MAKING THE MOST OF IN-PLANT FEEDING

The objectives of in-plant feeding are to supply the worker with food that is nourishing, sanitary, well-prepared, attractive, economical in cost, reasonably priced, and quickly served. These, combined with attractive surroundings that are comfortable and quiet, will provide relaxation and rest, thus protecting the employee against industrial fatigue.

On-the-job feeding requires feeding facilities. The final decision as to type, size, and distribution rests with top management and must take into account policies on length of lunch hour, staggering of lunch periods, finances, and similar matters.

Since the ultimate success of the in-plant food service depends upon its acceptance by the employees, it is wise procedure for management to include representatives of the workers in the discussions relating to planning of facilities.

The basic factors in determining the requirements for any industrial feeding installation, regardless of size, are: (1) The total number of meals to be prepared, (2) the meal pattern, (3) length and number of lunch periods, (4) plant area and distribution of employees, and (5) capital investment.

For those who have planning problems or who wish to check their own facilities, reference is made to *Industrial Feeding Facilities*, a publication of the Industrial Feeding Programs Division, U. S. Department of Agriculture, Washington, D. C. This publication contains detailed plans for various types of facilities. While standard layouts cannot be developed to meet all possible conditions, the plans are valuable as a general guide in planning.

Another important decision that management must make concerns operational procedure. There are three general types of operations: Contractor, company, and management-sponsored employee-welfare associations. All three types have operations at which one can "point with pride" or "view with alarm." In any type of operation the degree of success achieved depends ultimately on the active interest of top management. It is the responsibility of management to see to it that whoever has the food-service job does it in the best possible manner.

To insure satisfactory in-plant feeding, management must appoint competent managerial personnel who in turn can choose and develop an efficient, well-trained staff. Having made the choice of key personnel, management must give them authority, freedom, and opportunity in the food-service operation.

One of the easiest ways of destroying the effectiveness of the feeding program is to allow a situation to develop wherein the employees gain the feeling that the operation is an excessive profit-making venture at their expense. This can be avoided by giving employee representatives an opportunity to observe the financial aspects of the program.

Since price is such an important consideration in aiding or hindering the sale of food items, an important contribution can be made toward increasing the consumption of nutritionally valuable foods by judicious price adjustments.

Making available a special well-balanced luncheon at a low fixed price with no choice or a choice between only two entrees is one example of planning and pricing for good nutrition. In this connection there are industrial cafeterias which include milk as part of the "special," other beverages being additional. This procedure stimulates the consumption of vegetables and milk.

It is strongly recommended that price adjustments be made—even to a point below cost—on milk, fruit, and perhaps several other items which are found necessary for balancing the usual type of dietary in a particular plant area. The price differential can be offset, if necessary, by increasing the price of less nourishing items.

Where management has decided to call in a feeding contractor to operate its program, careful consideration should be given to the financial arrangements in order to guarantee the best service. The four most common arrangements are: (1) A fixed fee for service in which a flat sum is paid for operation regardless of income; (2) a fee for service plus a percentage of the gross income above a stipulated amount; (3) complete financial control invested in the contractor with no restriction on profit (this has become much less usual as management has come to realize the potentialities of in-plant feeding, and hence the need for supervision in its own interest); and (4) limited profit in terms of percentage of the gross income (usually 5 per cent or less).

Whatever the financial arrangement with the contractor, management's interests are best served by having on its staff a well-trained and experienced administrative dietitian for liaison and supervisory purposes.

Cooking as applied to large-scale preparation is steadily becoming more of a science as the discoveries of modern nutrition are applied.

It is being realized more and more that there are vitamins in food essential for life and it is also being realized that the "gentle art" of cooking can also remove large amounts of food essentials before they are eaten.

Vitamin C and vitamin B_1 (thiamine) are particularly susceptible to destruction in cooking, canning, and storage. These and other vitamins and minerals may be lost by solution in cooking waters which are thrown away or in the juices which run off.

Precautions should be taken to conserve nutritive value in foods; the following are given as examples of what can and should be done with vegetables: Wash quickly—don't soak, keep cool until ready to cook, cut just before using, place into boiling water for cooking, cook in minimum amounts of water, keep covered, serve in own juice or use juice in sauces or soup, and watch the clock—cook quickly—stop when tender; and with fruits: Serve fruit juice and tomato juice fresh—if they have to stand, keep covered and cold.

Serve safe food. Wherever perishable foods are involved, there exists the danger of food poisoning. Constant vigilance must be exerted through the routine practice of sanitation measures to prevent spoilage or infection that not only are unpleasant and dangerous for the workers affected, but that also give in-plant feeding a bad reputation.

It is recommended that 30 minutes be made the minimum length of the mid-shift period. Longer periods may be found necessary. Various surveys have shown that the time taken by workers for the actual consumption of their lunches ranges from 10 to 15 minutes. Those workers who eat substantial lunches generally take 15 minutes. Therefore this is the minimum time which should be allowed for the actual consumption of food. Varying additional allowances need to be made for cleaning up, going to and from the eating place, and for time spent in the food service line, usually a total of 30 minutes.

The home-packed lunch should be given attention since a large number of workers still bring their own lunches. Pleasant, strategically located lunchrooms may be feasible, in which milk, salads, and other foods may be purchased to supplement the packed lunch. Proper refrigerated storage space for holding packed lunches until mealtime should also be provided.

Short rest periods at the end of the first and third quarters of a shift have a beneficial effect in combating industrial fatigue and in sustaining morale and production. The combination of these rest periods with attractive supplementary foods makes them still more effective since food has definite psychological as well as physiological and nutritional virtues.

The establishment of an educational program in industry, directed to helping the worker improve his selection of food, has been found valuable to labor, management, and the food-service operation.

Attempts to improve food selection may be considered to have two aspects. Those activities which tend to make the worker improve his food habits through food display, price adjustments, improved food preparation, and luncheon specials may be termed "indirect" nutrition education. The campaign to appeal to his desire for health and well-being through proper eating may be called "direct" nutrition education. Both approaches are valuable and should be combined.

SPECIAL PROBLEMS IN INDUSTRIAL FEEDING

Some of the problems confronting small plants are: They have a minimum of personnel management staff with which to investigate technical details of in-plant feeding and to carry the accompanying responsibilities of organization and operation; the financial outlay for the food-service installation and personnel is a proportionally greater problem; food contractors are not interested because of lack of sizable profits; and the inability of government industrial feeding specialists—through lack of time—to work with as many small plants as desired or necessary.

Suggested solutions to the small plants' problems have been many, some of which are: A central kitchen may be built and equipped to prepare and dispatch food to each of the participating plants; a food concessionaire may be engaged to service the entire group; or a self-contained cafeteria may be established near or in one or more of the centrally located plants where the employees of all the co-operating plants can eat.

Where a plant is too small to operate its own cafeteria and where the foregoing procedure cannot be developed, a lunchroom may be established, where home-packed lunches can be eaten and where hot soup, sandwiches, salads, and beverages may be purchased. Plant personnel can easily operate such a simple service with the co-operation of management and labor.

White-collar workers who work in congested city business areas generally eat in near-by restaurants, cafeterias, snack bars, and drugstore fountains. These are usually crowded. Many individuals have to eat their meal while standing up. Under such conditions eating becomes a hurried, uncomfortable, and frequently expensive chore.

It is recommended that individual employers, white-collar employee organizations, associations of employers, community nutrition and health authorities and organizations, and the management of large office buildings co-operate in: (1) Surveying existing feeding facilities and practices in particular buildings, and in congested business areas; (2) correlating these findings with actual needs; (3) drawing up recommendations for facilities, requirements, operational methods, and for nutritive education; (4) seeing to it that the recommendations are carried through; and (5) establishing a permanent supervisory agency.

SPECIAL NUTRITION PROBLEMS IN INDUSTRY

Proper food involves more than individual vitamins and minerals. Nevertheless, fortified foods and vitamin-mineral supplements should be considered in the process of achieving over-all good nutrition.

Of special interest to those responsible for feeding industrial workers are enriched white flour and bread and fortified margarine.

In those states where simple goiter (an iodine-deficiency disease) is of regular occurrence, it is recommended that only table salt which has been iodized be used as a means of assuring a higher intake of iodine.

It has been demonstrated that large sections of industrial workers do not achieve the recommended dietary allowances in their usual dietaries. This finding does not mean that widespread severe nutritional deficiencies exist. It does mean that the standards which have been established to guarantee an optimal nutritional contribution to good health are not being completely met and that mild degrees of deficiency may be common.

It is recommended that management, labor, and the physicians and nutritionists in the industrial field adopt the following basis for action in improving the nutrition of workers:

(1) The recommended dietary allowances, when attained, are assurance of adequate nutrition; (2) the basis for attaining this goal is for every worker to eat a well-balanced diet; (3) this means prolonged, persistent, and attractive nutrition education in the plant and in the home; (4) such a program must include adequate in-plant feeding facilities, reasonably priced, attractive, and nourishing meals, food preparation and service designed to maintain to the greatest degree the nutritional value of the raw food, and a survey of food habits and analysis of the nutritional value of foods eaten by the employees; (5) where it is apparent that a significant number of workers are eating in such a way as not to receive the recommended dietary allowances, nutritional supplements might be issued as part of the nutrition education campaign in order to point out and immediately correct discrepancies. Such nutritional supplements may consist of vitamins or vitamin-mineral preparations or enriched or fortified foods, designed to be part of the mid-shift meal or between-meal feedings; (6) the progress of the nutrition education program should be checked at intervals and the composition of the nutrition supplement altered as found necessary to take into account dietary improvements; and (7) wherever possible, adequate records should be kept and published so that industry and nutritional science may benefit from the results.

Regardless of whether supplements are used or not, the key recommendation stands: Industrial feeding programs should incorporate proper nutrition education.

The nutrition of industrial workers involves many complex problems and situations. Unfortunately, the answers to many questions cannot be given because of the absence of necessary research and study of conditions obtaining in industry. In addition, it is not always possible to take over information or techniques applicable to nonindustrial situations and apply them with assurance to industry. This field invites the attention of industrial and Government research organizations.

TOWARD A SCIENCE OF SOCIAL SELF-CONTROL[1]

By DORWIN CARTWRIGHT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

NATURAL science and engineering have reached such an advanced stage of development that the economic costs of destroying Western industrial civilization do not far exceed the resources of the major powers. Soon, technology will have given us the power and ability to commit social suicide even though it may take years of preparation to carry it off. Of course, none of us wants to destroy our civilization, but none of us wanted to come as close as we did in the last few years. Never have the people of the world gone so reluctantly to war as in 1939–1941, and yet the heart of Europe now lies in ruins. The horrible fact is becoming increasingly plain that, once we are able to put an end to the modern world, we may proceed to do it in spite of ourselves. Unless we can make a sharp break in the trend of history, it looks very much as if progress in technology will only hasten the day of our doom.

What is the reason for this tragedy? Why should progress in the natural sciences lead us inevitably to our destruction? The answer is essentially simple. It is human beings who completely determine *how* the fruits of science are to be employed. Whether scientific discoveries are used for the betterment or destruction of the world depends upon the behavior of human beings living in a complicated and malfunctioning society. As long as our social structure produces conflicts between nations without also providing social institutions to guarantee their peaceful reconciliation, technological advances simply increase the destruction wrought in these conflicts. The only hope, then, for avoiding the devastating consequences of modern war is to avoid war. This end can be accomplished only through the rapid development of techniques of social self-control.

But society cannot control itself without a developed social science. Without knowledge of the determinants of social behavior we cannot hope to devise techniques that will prevent these disastrous conflicts. The fundamental danger of our era of technology lies in the fact that the social sciences have developed more slowly than the physical sciences. We have been given power before we know how to make it serve our needs. This lag of the social sciences behind the physical sciences has brought about social waste and disruption since the dawn of the industrial revolution, but the stakes have never been so large before. Mass unemployment, labor strife, the breakdown of stable family life, delinquency, and gangsterism result basically from technological changes to which we have not made appropriate social adjustments. The use of technological knowledge in modern warfare to destroy industrial civilization is but a branch of the same tree.

The problem, however, is not simply that social science has developed slowly, although it is far behind the natural sciences. The application of social scientific knowledge has also met with incredible difficulties. Principles generally accepted among social scientists are violated every day by men of action. Problems of social organization are inefficiently solved or completely bungled when the use of knowledge and techniques developed by the social scientists would reduce waste and make for smoother functioning. Unfortunately, too many men charged with the responsibility for directing the course of events in the world of affairs feel that common sense and "practical experience" are sufficient maps for steering their course.

A recent book by Dr. Alexander H. Leighton entitled, "The Governing of Men,"[2] makes a substantial, though indirect, contribution to the solution of the problems considered here. Although no discussion of war or its causes is included in the book, Leighton describes principles of social behavior which are fundamental to any program of social self-control. Moreover, he puts his conclusions in such a concrete and specific form that anyone who has to deal with groups of people in industry, government, or community life, can apply them to the day-to-day problems which arise.

Leighton is a medical doctor with psychiatric and anthropological training. His Navy assignment during the war placed him as research director in the Poston, Arizona, Relocation Camp for the detention of Japanese civilians living in this country. With a staff of trained social scientists, he made systematic observations of what happened in this camp throughout its hectic history. His report is a record of conflict, tragedy, and administrative disorganization, with high spots of intelligent leadership, high-minded determination, and gratifying success. It is fascinating, dramatic, instructive, and disturbing. Drawn from direct experience with the difficult administrative problems which arose from taking people out of their homes and establishing them in a new community, this book deals with fundamental factors in the make-up of people. It digs deep into the recesses of human motivation.

Cast against the background of our urgent need for major social scientific advances, however, this book seems but a minute step toward solving our fundamental problem. Nothing revolutionary is presented; no atomic bomb of social science is revealed. Still, the book is significant and deserves careful reading by any who wish to apply the findings of social science to social relations of any sort.

The book is significant because it does two things and does them well. First, it describes in concrete detail the kinds of difficulties administrators can get into if they do not take full advantage of known social scientific techniques and principles. It analyzes with penetrating insight and skill the social forces at work in Poston which produced frustration, strife, crises, and ultimately a mass strike against the administration of the Relocation Center. Common mistakes made in managing people are presented dramatically and in a way that gives them general significance for other types of situations.

But Leighton does not confine himself to errors and negative conclusions. He makes a positive contribution besides. The book is divided into two major parts. The first consists of a careful and detailed description of the course of events at the Relocation Center and of the broader social background of the Center. As a job of reporting it is superb. Experienced newspaper reporters could well be envious of his style. The second part of the book is devoted to a systematic discusson of the generalizations that can be made from this case study. In this part, forty-nine principles of social behavior are presented and described in detail. While other social scientists may quarrel with the formulation of some of them, there can be no doubt that men responsible for dealing with groups of people can improve their efficiency of operation greatly through mastering these principles and putting them into action. As a particular aid to those who want to apply the principles, Leighton also presents his conclusions in the form of specific recommendations for action.

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[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "The Governing of Men," by Alexander H. Leighton, Princeton University Press, Princeton, N. J., 1945.

An administrator would do well to use these recommendations as a check list against which he periodically evaluates his own performance for himself.

Since social science has not yet developed to the place where it is possible to state unequivocal and generally accepted "laws," perhaps the major contribution of this book lies in the point of view or frame of reference which it displays. Rather than viewing human behavior as a result simply of the intrinsic properties of the individuals, such as their personality traits or "human nature," Leighton attempts to understand social behavior as a result of the social, economic, political, and cultural influences which play upon all the people involved, including the administration. Social science has progressed far enough to know that this is the proper approach. To understand why people behave as they do, one will make little progress if he readily frames his description in terms of "stubbornness," "the sneakiness of the Japanese," "power drive," or the like. Only by understanding the needs of the people as they derive from their customary social organization and way of doing things, only by concentrating upon the meaning of the situation to the other fellow, only by understanding the demands upon people made by their position in the social structure—only by such a point of view can intelligent action be taken in any given job of administration.

Leighton also performs quite a different service in this book. Through his vivid account of the American citizens of Japanese descent and of their alien parents who were forcibly uprooted from their homes and businesses, he preserves for posterity an historical record of the tragic consequences in human suffering of the mass hysteria which swept the West Coast following Pearl Harbor. Fanned by the winds of long-standing racial prejudice, the fears generated by the attack on Pearl Harbor led to precipitous and ill-conceived actions against all people of Japanese descent or origin regardless of their loyalties or behavior. Forced to dispose of their businesses under conditions producing the most extreme exploitation, forced to break all ties with their communities, accused in the public press of disloyalty simply because of the accident of their origins, brought into the middle of a desert and housed in flimsy barracks, and given promises that were never fulfilled, these people stand victims of social malfunctioning in our own country in our own era of enlightenment. Complacency based on satisfaction with our present stage of social scientific development cannot help but shrivel up under the burning light of Leighton's objective description of the people who lived in our own concentration camps.

No attempt is made in the book to account for the influences which brought about the mass evacuation of the Japanese from the West Coast. This task would require a major study in itself. Moreover, it is an unfortunate fact that as we confront problems of such large scope our present understanding of causes rapidly diminishes. It is not yet generally realized that the scientific study of social problems of such magnitude requires the utilization of large numbers of research personnel and, consequently, the expenditure of large sums of money. Leighton, with a relatively small staff, could make real progress in understanding the causal influences at work within the Relocation Center, but he would have been greatly hampered in any attempt to study scientifically the causes which produced the Center. Until society is ready to put as much money and personnel into research in the social sciences as it does in the physical sciences, we may expect the lag of the social sciences behind the physical sciences to continue to increase. The consequences of this "economy" may be too costly for us to pay.

European Automobiles

IN addressing one of the sessions at the summer meeting of the Society of Automotive Engineers held June 2–7, 1946, in French Lick, Ind., Lawrence Pomeroy, technical editor of *The Motor*, London, England, revealed that the design of European automobiles is trending toward small, light, streamlined motor vehicles featuring economy. Through the application of aerodynamic principles to reduced wind resistance and better highway construction, European car performance is comparable to that of American, with much greater fuel mileage.

Economic factors prescribe that normal European cars should not exceed 2000 lb all-up weight and should be capable of at least 30 mpg in day-to-day running. Improved body form will permit such cars to sustain road speeds of 70–80 mph, and this will make the small economy car increasingly competitive with the larger types. This competition will be fortified by world developments in motor roads which will mask the inherent limitations of the small car in the aspects of hill climbing and acceleration.

The European car, Mr. Pomeroy said, must have a material and man-hour content not greater than one third that of American vehicles. Increasing attention is being given to designing 1000-lb cars, which were described as being capable of challenging American cars in speed and durability and exceeding them greatly in fuel economy. Wind-tunnel tests were reported to have revealed the possibility of reducing resistance and drag by one half to two thirds, with resulting large gains in speed, fuel mileage, and longevity, but also to have indicated that such gains are greater with small models than with large.

Motor roads on which gradients are held to 4 per cent and cross-traffic is eliminated, plus installation of automatic transmissons in small cars, were described as tending to make acceleration and hill-climbing ability less important.

Recalling that in the United Kingdom, the most prosperous country of Europe, where 78 per cent of potential car-buyers must have the utmost in economy, 15 per cent must make close studies of operating costs, and only about 7 per cent are able to buy cars on the basis of preference and performance, Mr. Pomeroy explained that the 2000-lb car will be the top limit for all except the wealthy few, or government officials.

As examples of European design trends, Mr. Pomeroy described the French "Mathias," a three-wheel model, with aluminum-alloy one-piece body and chassis, and a 15-hp two-cylinder opposed engine giving speeds of 50 mph, perhaps, but fuel mileage as high as 94 mpg. At the other end of the scale, he said, is the German "BMW," which has a six-cylinder engine giving speeds exceeding 100 mph with fuel mileage on the order of 20 to 30 mpg.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Atomic Energy Control

A REPORT on the international control of atomic energy has been prepared for the Secretary of State's Committee on Atomic Energy by a board of consultants consisting of Chester I. Barnard, president, New Jersey Bell Telephone Company; Dr. J. R. Oppenheimer, California Institute of Technology and University of California; Dr. Charles A. Thomas, vice-president, Monsanto Chemical Company; Harry A. Winne, member A.S.M.E., vice-president in charge of engineering, General Electric Company, Schenectady, N. Y.; and David E. Lilienthal, chairman, also chairman of the Tennessee Valley Authority.

The report is a preliminary study of the international control of atomic energy. It has been prepared to contribute to the clarification of the position of the U. S. representative on the United Nations Commission on atomic energy set up by resolution of the United Nations General Assembly to inquire into all phases of this question.

The board of consultants met for the first time on Jan. 23, 1946, conferring briefly with the Secretary of State's Committee on Atomic Energy regarding the board's assignment to study this problem. For more than seven weeks after that time they devoted virtually their entire time and energies to the problem that had to be studied and reported upon. The plants and installations at Oak Ridge, Tenn., and Los Alamos, N. M., were visited. Days were spent consulting with numerous scientists, industrial experts, and geologists, authorities in the technical fields concerned with atomic energy. Since Feb. 25, 1946, the board has met almost continuously, developing and writing this report.

Some of the main reasons which have influenced the people of the United States and its government in this course were first definitely formulated in the Agreed Declaration of Nov. 15, 1945, issued by the President of the United States and the Prime Ministers of the United Kingdom and Canada.

The Agreed Declaration cites three reasons for seeking international control: First, it recognizes that the development of atomic energy and the application of it in weapons of war, have placed at the disposal of mankind, "means of destruction hitherto unknown;" second, that there can be no adequate military defense against atomic weapons; and third, that these are weapons . . . "in the employment of which no single nation can in fact have a monopoly."

The report consists of four sections. In Section I the board examined the reasons that have led to a commitment for the international control of atomic energy and the early proposal for realizing this objective by a system of inspection. In Section II the essential characteristics of a workable plan for security are stated, and the considerations that favor the development of a plan are set out. In Section III the essentials of an organization that puts such principles into effect are described. In Section IV the problem of the transition period leading from the present to the full operation of the plan are considered.

A letter of transmittal from the Committee on Atomic Energy to the Secretary of State says in part: "In our opinion it (the report) furnishes the most constructive analysis of the question of international control we have seen and a definitely hopeful approach to a solution of the entire problem. We recommend it for your consideration as representing the framework within which the best prospects for both security and development of atomic energy for peaceful purposes may be found."

The Committee on Atomic Energy consists of Dean Acheson, chairman, Vannevar Bush, James B. Conant, Leslie R. Groves, Major General, U.S.A., and John J. McCloy.

Reprints of this Department of State report (publication 2498) are for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

"The intensive work," says Secretary of State Byrnes in the foreword, "which this document reflects and the high qualifications of the men who are concerned with it make it a paper of unusual importance and a suitable starting point for the informed public discussion which is one of the essential factors in developing sound policy. The document is being made public not as a statement of policy but solely as a basis for such discussion."

Russian Science Plan

EXCERPTS from a report by Academician S. Vavilov, president of the Academy of Sciences of the U.S.S.R., appearing in the May, 1946, *Science Bulletin* of the American-Soviet Science Society, reveal the following facts regarding the Russian five-year plan of science:

Problems of physics and chemistry and also technical sciences hold an especially important place in the five-year plan of the Academy. This was largely determined by the present-day development of science and by the particular importance of the afore-mentioned branches.

Physicomathematical sciences are represented in the plan by a number of problems connected with the study of the atomic nucleus and of cosmic rays. Physicists working in connection with other specialists will analyze unusual phenomena peculiar to this branch of science and will work out methods of liberating nuclear energy, which holds out such great prospects to humanity. There is no doubt that in time the application of this energy will provide a new solution for problems of power transport and for other problems. Physicists will continue research into the properties of substances at temperatures close to absolute zero. A considerable amount of work will be devoted to the introduction of oxygen into the technological processes of industry.

The plan includes the investigation and application of semiconductors and new high-molecular compounds. Much attention is devoted to astrophysics. Gigantic laboratories permit astronomers to study many important phenomena with the help of spectrum analysis and other methods. Like physics, astronomy approaches very closely to the problem of nuclear energy. The study of high-speed gasodynamic processes is of great significance for the construction of superswift aircraft, artillery, and also for other technical branches. These problems are reflected in the plans.

A comprehensive program awaits Soviet chemists. There is no doubt that work on the theory of chemical affinities, on energy and the structure of chemical combinations, the mechanism of chemical transformations, and the study of nuclear reactions, will be widely developed. Efforts will be made to determine the exact yield of decomposition products obtained from nuclear reactions and their quantitative and energy characteristics.

A very comprehensive program has been drawn up for the department of technical sciences. Among questions of great importance are the following: Development of the theory of the stability of movement and oscillation of mechanical units, problems of durability and stability of structures, aerohydromechanics of the wing theory of machines and mechanisms. Research on the underground gasification of coal is to be resumed, and problems of high-pressure and high-temperature steam will be further developed. Provision is also made for the development of research in the field of electrotechnique, in particular, transmission of electric energy by high-tension current. Urgent tasks confront specialists in petroleum and solid fuels. Mining problems will be broadly represented in the plan of the department of technical sciences. Research into problems of communications, and in particular of short and ultrashort radio waves, is to be extended.

The necessity for building scientific institutes has been pointed out by Stalin. Many hundred millions of rubles will be spent on the construction of institutes for the central building of the Academy and on dwelling houses for scientists, in the course of the next five years. The list of major constructions for 1946 to 1950 includes some 50 objectives. In addition to the central building, there will be erected institutes of organic chemistry, metallurgy, machine-building, mechanics, automatics and telemechanics, mining, and others.

Construction of the Institute of Chemical Physics, now under way, will be continued. The building of the Institute of Physics will be enlarged. The Central Astronomical Observatory in Pulkova, which was razed to the ground by the Germans, and the Astrophysical Observatory in the Crimea will be rebuilt. Considerable funds have been assigned for the foundation of a teleseismic station in Pulkova, a hydrophysical station in the Crimea, and similar projects. The Institute of Organic Chemistry, for which a building will be erected in the immediate future, is to solve various problems of great national economic importance, such as those of synthetic rubber, artificial fibers, organic dyes, and chemical pharmaceutical products. This Institute is to deal with the problem of the rational utilization of natural gases, the synthesis of saturated hydrocarbons, the utilization of wood waste, and the synthesis of new kinds of rubber.

Another task of immediate urgency is the construction of a building for the Institute of Metallurgy which is also confronted with problems of great national economic importance, the elaboration of new technological processes for the iron and steel and nonferrous-metals industries, new types of alloys, refractory materials, and similar problems. In addition to its laboratories, the Institute will be provided with premises and equipment permitting it to carry out experiments on a semi-industrial scale.

In connection with the great importance attached to questions of acoustics, an acoustical laboratory is being equipped in Moscow fitted up for varied research, in particular, on architectural acoustics.

EXCHANGE OF STUDENTS AND SCIENTISTS

The Soviet Committee on Higher Schools (Vsesoiuznyi Komitet po Delam Vysshei Shkoly) has set up a foreign department headed by Prof. Nikolai Chemodanov. Its function was outlined by the professor in an interview with newspapermen. He said: "The new department will maintain contact between Soviet higher schools and educational and scientific institutions abroad. With this end in view, it is proposed to organize the exchange of scientific literature and textbooks. Soviet scientists going abroad will lecture and take part in international scientific congresses. The foreign department will direct the studies of foreigners who will be admitted to higher schools of the U.S.S.R. by special decision of the Soviet Government. In their turn, Soviet students and scientists will visit various countries to study the experience and work of higher-educational institutions abroad, and to improve their own knowledge."

Lightweight Helicopter

DEVELOPMENT of a lightweight military helicopter by G & A Aircraft, Willow Grove, Pa., in co-operation with A.T.S.C., is revealed in the May, 1946, issue of *Aviation*. The company is a subsidiary of Firestone Tire and Rubber Company.

Designed for courier duties, the XR-9B, as it is called, is powered by a 135-hp 4-cylinder Lycoming engine, and is stated to have a top speed of more than 150 mph. Fuel capacity is 25 gal of 80 octane, enough for more than three hours of flight. Preliminary data indicate that cruising speed will be about 80 mph, service ceiling over 10,000 ft, and rate of climb better than 1000 fpm.

In flight, directional headings are effected by torque correction from the tail rotor through use of rudder pedals. Horizontal flight in any direction is obtained through cyclic pitch control using a conventional control stick. Vertical ascent or descent is made by means of simultaneous pitch control interconnected with manual throttle to assure sufficient power and rotor rpm.

An electric-hydraulic governor, acting upon simultaneous pitch control, is stated to maintain constant predetermined rotor speed regardless of throttle condition or power used. Thus vertical control is effected entirely by using the throttle—the governor providing simultaneous pitch control. A unique rotor head of G & A design is said to virtually eliminate vibration.

The main rotor is three-bladed and uses an N.A.C.A. airfoil. Chord at the root is 15.25 in. and at the tip 8.5 in. Blade surface area is 12.5 sq ft. The two-blade tail rotor, using an N.A.C.A. section, is 6 ft 6 in. in diameter with chord measuring $6^1/_2$ in. at the root and 3.8 in. at the tip. Blade area is 1.125 sq ft.

Rotor blades are made of step-tapered heat-treated steel-tube spars to which $^7/_{32}$-in. five-ply poplar-plywood ribs are attached by stainless-steel collars. Leading-edge strips are spruce over the inboard half of the blade and maple over the outboard half, and they have lead ballast embedded. Trailing edges are of spruce. Top and bottom surfaces of the framework are covered with $^1/_{32}$-in. three-ply mahogany with poplar core. Blades are fabric-covered and doped.

The fuselage is made up of welded steel tubing, covered with aluminum alloy, and there is a large lucite nose section for maximum visibility. The high-mounted boom has a balsa core with an Alclad skin covering. Only eight instruments are mounted on the simplified instrument panel.

Ease of disassembly for shipment or storage is noted. The

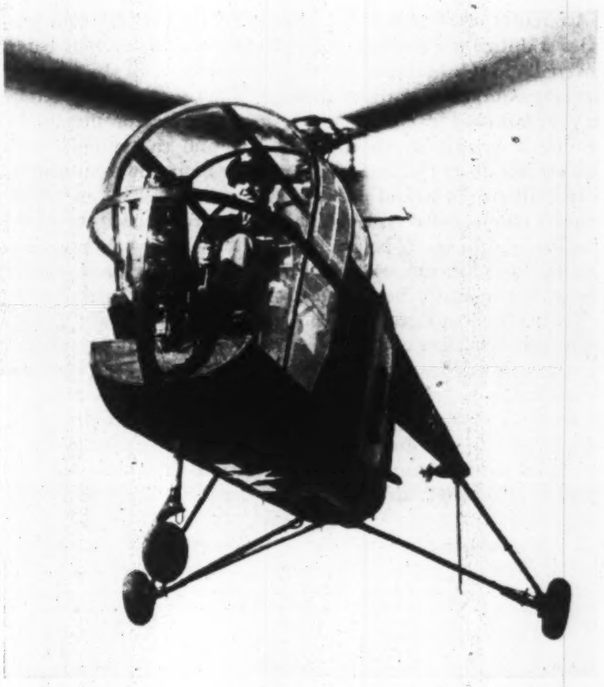

FIG. 1 NEW XR-9B HELICOPTER HOVERS DURING TRIALS AT WRIGHT FIELD

(Landing gear is fixed tricycle, and there is a skid at the tail to protect the antitorque rotor. A top speed of more than 100 mph is claimed, using a 135-hp Lycoming engine.)

tail section can be detached by removing six bolts and two control wires. Rotor blades are removed by taking out three bolts and three pins and by unseating three ball-and-socket joints. Two removable panels on each side of the fuselage provide access to the engine and transmission; and three panels in the boom aid maintenance and inspection work there.

Planning has already proceeded with a view to postwar commercial possibilities of the XR-9B. It is indicated that this civil version will feature a larger cabin.

Eliminating Castings Defects

THE basic causes of defects in castings, according to an article by Pierce Boutin, Pontiac Motor Company, Pontiac, Mich., in the *American Foundryman*, March, 1946, result from the use of metal which has varied outside the limits of desirable analysis, or which is poured too cold or too hot, or contains impurities which travel into the casting. Dirt inclusions may be caused by careless molding and coresetting practice. Blows and misruns can be caused by the misuse of oil in cores, or water in molding sand, by improper venting, improper gating, cold iron, or lack of sufficient thickness of metal, and many other factors.

Starting at the period after solidification, cracks may be caused by rough handling, or by too rapid cooling. Hard spots may be caused by lack of attention to grinding wheels. Dimensional defects may be caused, both before and after the period mentioned, by improper pattern mounting, improper setting of cores, too-light chaplets, sloppy flask bushings, and improper clamping of the flasks, or by unclamping too soon. Also, in the casting the improper grinding of locating pads or overgrinding generally results in dimensional defects.

The period between the start of pouring and through final solidification rates very high in importance, for during this period occur most of the mysterious happenings which baffle foundrymen.

METAL FLOW

As an example, it is everyday knowledge in the foundry that two molds may be made from the same batch of sand, the cores in each mold made from the same sand and all properly vented, both molds poured from the same ladle of iron, and with the result that one casting is good and the other defective and showing considerable metal disturbance.

When liquid metal enters the sprue it travels down to the next part of the pouring system, probably a horizontal runner, which has a reduced flow area or "choke." This choke permits the sprue to fill, reducing the downward velocity and floating impurities back to the highest metal level.

Each successive part of the pouring system is thus reduced in flow area, or choked smaller than the part which feeds it to prevent the progression of impurities which were present in the metal or picked up on the way to the mold proper.

The amount of total choke between sprue and gates should not be so great as to cause excessive gate pressure or "squirt." This might lead to the cutting of cores or molds, or splashing upon the higher core levels and causing cold spots. Also, insufficient difference in the flow areas between sprue and gates results in a sluggish flow of metal through the gates and encourages the formation of blows and cold shorts.

The introduction of metal into the mold starts a series of changes which, by their type, magnitude, and timing, influence the quality of the final casting. One of these changes is the rapid increase in the surface temperature of cores and mold, as contrasted with the relatively slow temperature rise in the secondary layers back of these surfaces. This causes expansion differences and shear stresses that lead to scabbing, and should this expansion have considerable depth, and still lead to rupture, the result is termed a buckle.

GAS PRESSURE

Another effect of the introduction of heat into the mold is to start the evolution of gas from cores and molding sand, which builds up pressure in the mold, forcing gas out through the molding sand and mold vents. The gas produced in the cores, at this stage in the pouring, moves mainly outward into the mold and only partially through the core vents.

As the metal level rises in the mold it gradually covers the surface of the cores until finally all core gas must move out through the core vents. Or should the relief through the vents be inadequate, back pressure is built up, forcing gas back through the metal, causing a boiling action and blows, and if this back pressure prevents the metal from completely joining over the cores, the result is a misrun.

At the stage where the metal is about to cover the top of a core, maximum buoyancy is applied to the core and the strain against core prints and chaplets reaches a maximum.

At the instant metal starts flowing into a mold it hastens in the direction of final solidification. Metal skins are formed against cores and molding-sand surfaces, the metal flowing between these skins; and particularly in areas not in front of the gates, this liquid metal moves with an ever-increasing viscosity.

This skin-forming tendency is most important for it keeps the sand from being continually attacked by fresh metal and promotes good casting finish. On the other side of the ledger, these skins discourage flow, especially in thin sections, and prohibit the removal of gas out of the metal through the molding sand.

As the metal level reaches the top of the mold the effective head pressure from the pouring system is suddenly added to the pressure caused by the weight of metal in the mold to produce the maximum strain against mold surfaces. This is the instant when most sags or swells are started.

With the mold filled with metal which varies all the way from liquid to semiliquid to solid, the casting progresses on to complete solidification. At this stage all mold vents are useless and any gas or other impurities present in the metal at this time are there to stay.

As the metal continues on to complete solidification there is a shifting of the liquid from the more fluid to the less fluid sections of the casting as the result of normal shrinkage. Shrink holes, tears, and dendritic areas occur when this exchange of metal is restrained or prohibited.

The final movement of metal should be through the gates and feeding the areas directly in front of the gates. During this period any swelling or outward movement of a core print or bleeding through a core print or into a vent may cause a recession of the metal resembling a shrink or even a blow.

This attempt to visualize changes that take place in the shaping of a casting is not a complete picture. Many facts have been omitted mainly because the author does not know them. But the troubleshooter should attempt continually to understand the various changes in the order of occurrences, and make them part of his reasoning equipment when tracing a defect back to its source.

From the standpoint of profit and loss, however, it is not enough merely to correct trouble. The real benefits are derived from the prevention of trouble. Therefore once the cause of a defect is found, all steps should be taken for a "follow through" to prevent the recurrence of that defect.

Gating systems should be checked regularly for dimension changes due to core-box or pattern wear. Core venting can be checked by time spent in the core room, in the study of the gassing of molds, and in breaking up scrap core assemblies.

Core-setting practice should be observed often for rough handling or improper positioning of cores. The amount of touch on prints and chaplets should be checked often by dusting the assembled cores, and then coping and removing the cope. Castings studied in the shake out will show vent metal or bleeding spots.

Castings studied before cleaning tell a story by the amount and thickness of shiny spots; and the relative coloring of sand is related to the direction of metal flow. The presence of "burnt-in" sand indicates agitation or possibly means that the metal had contacted the sand and then receded, destroying the mold skin, and then followed with recontact and penetration.

The cleaned casting may reveal evidence of sloppy flask or pattern bushings, excessive chaplet pressure, and if broken or sawed up, can show section thickness, excessive finning, or early collapse of cores.

Steel Diving Chamber

A NEWLY developed steel diving chamber large enough to house an operator, gravity-meter instruments, oxygen, and air-purifying equipment is slated to be put into operation shortly by Union Oil Company for use in underwater-gravity-meter surveys off the Louisiana coast, according to an article by Gilbert M. Wilson, in the April 29, 1946, issue of *The Oil Weekly*.

Measuring 5 ft tall and 3 ft in diameter, the all-welded chamber is constructed of $^1/_2$-in. steel plate which is heavily galvanized. A round hatchway in the top is provided with rubber-gasketed pressure-seal and locking device, the latter capable of being opened from either side.

A circular two-ton lead weight attached to the bottom provides stability for holding the chamber erect while it is being lowered and while it rests on the ocean floor. In the event of hoisting-equipment failure or other emergency, this weight may be released from the inside by the operator merely by turning a handle inside the chamber, and the cylinder will quickly shoot to the surface as a result of its own buoyancy. It is built to withstand pressure at depths in excess of 100 ft. In tests conducted recently off the California coast the vessel was lowered to 160 ft below the surface with very satisfactory results. In addition, extensive tests have been conducted in the same area at depths of from 25 to 35 ft.

The technician operating the gravity meter sits on a cushioned seat equipped with a safety belt, the latter to prevent his being upset and injured if the chamber should be tipped over in the water, or, if the weight block would have to be released, to send the chamber and its occupant bobbing to the surface. In addition to the gravity-meter instruments, the chamber is equipped with two-way communication facilities, test apparatus, chemical air-purifying equipment, and emergency oxygen.

Telephone cable is attached to the outside of the upper surface of the chamber and is independent of the heavy cable with

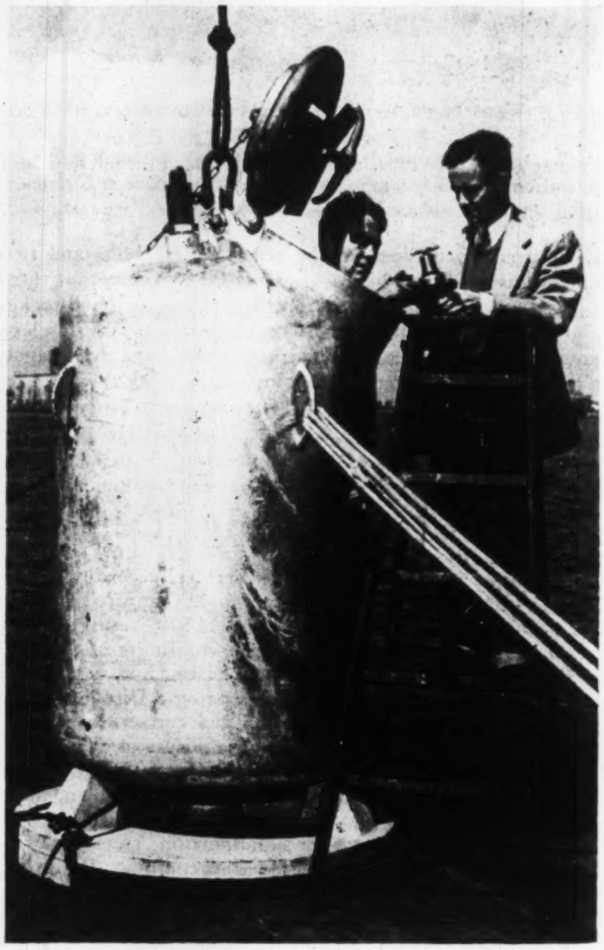

FIG. 2 DIVING CHAMBER BEING READIED ABOARD A BARGE FOR ONE OF ITS INITIAL TEST DIVES OFF THE CALIFORNIA COAST

(In an emergency, the two-ton stabilizing weight attached to the bottom may be released by the technician within the chamber, permitting cylinder to come to surface.)

which the chamber is hoisted in and out of the water. Handles welded to the outside of the cylinder provide a means of attaching lines used in stabilizing the unit as it is lowered over the side as well as for grappling when it appears above the surface.

Detection of salt-dome-type structures is expected to be simplified through use of this diving equipment which allows the gravity meter to be rested solidly within two or three feet off the ocean floor and for any desired length of time. It is commonly known that salt-dome structures currently being drilled probably continue for many miles off shore, and the diving bell containing the instruments is intended to speed up and greatly simplify the exploration of these possible oil-bearing areas. Comparatively little equipment is required in carrying the device since it is operated from a barge equipped with boom and rigging capable of handling the chamber.

Plastic Lenses

According to an article in the May, 1946, issue of *Science and Appliance*, clear plastics have been molded for use in optical lenses. The newsworthy part of this development is the information that such lenses were used extensively during the war, a fact that was largely blacked out for security reasons. Recent extensions of the use of this material to large-size lenses are also interesting.

Lens grinding is an exacting and time-consuming occupation. The demand for optical components for telescopes and viewing instruments in the program for the production of armaments was met quickly, according to reports of the manufacturers, by the plastic lenses that could be molded accurately in molds of glass precisely ground to the required shape. The lenses had the advantage of being light and easily machined to shape, with the disadvantage of scratching more easily than glass. Just as different glasses are used in optical systems to take advantage of different indexes of refraction, plastics of different optical properties were used in combination.

Since the war, one of the uses to which plastic lenses have been put is to magnify the television images of home receiving sets. Plastic lenses to accomplish this magnification can be made without excessive cost, it is stated. Television images large enough for projection on a theater screen are considered a possibility.

Cloud Range Meter

The cloud range meter was one of the devices developed during the war for measuring cloud ranges and ceilings. It was developed to provide a portable equipment which would give an instantaneous reading of cloud range and elevation angle under day or night conditions, and which could be operated with low-power portable generators.

An article in the *General Electric Review*, April, 1946, by Frank J. Moles, General Engineering and Consulting Laboratory, General Electric Company, describes the principle of operation and the apparatus employed.

The principle of operation is similar to that of radar, except that light pulses are used instead of radio pulses. The time taken by the light pulse to reach the cloud and return to the point of origin is a measure of the distance or range, since the velocity of light is known. This time is measured by suitable timing circuits, and the distance is indicated directly on the calibrated scale of a cathode-ray oscilloscope tube.

The operation of the equipment is as follows: The transmitter consists of a high-voltage spark gap at the focus of a paraboloidal reflector. This unit is arranged to project a beam of very high-intensity light flashes of very short duration (about one microsecond or one millionth part of a second). These flashes are produced by the discharge of a capacitor through a spark gap. The capacitor is charged to approximately 10,000 volts and discharged through a very low-impedance circuit to obtain high-intensity light pulses. The spark gap has aluminum electrodes $^1/_4$ in. in diameter—chosen because they produce a spectrum which approximately matches that of the photocell and because they have a reasonable life. The flashes are repeated at regular intervals; 60 times per second.

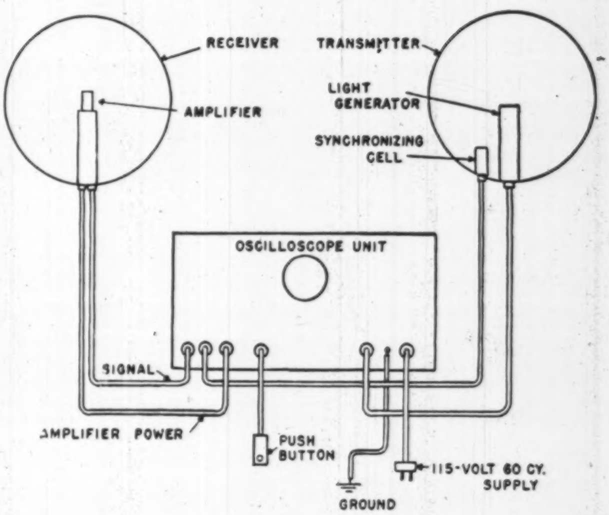

FIG. 3 INTERCONNECTION OF THE VARIOUS ELEMENTS COMPOSING THE CLOUD RANGE METER

The transmitter is controlled by a push button on a flexible lead and is operated only when observations are being made. The reflector can be aimed in any direction. When it is aimed at a cloud bank or other reflecting surface, a small part of each light flash is reflected back to the receiving mirror. This is also a paraboloid, at the focus of which is a photocell. The short pulses of returning light are converted by the photocell into voltage pulses which are amplified for further use. The high-gain video amplifier used for this purpose is mounted adjacent to the photocell and in the assembly to keep the high-impedance circuits as short as possible. The receiving mirror is mounted on the same support as the transmitter and is aimed in the same direction, so both move together.

The indicating unit of the system is a special cathode-ray oscilloscope which measures the time required for each pulse of light to travel out to the reflecting surface and back. Since the velocity of light is known, this is a measure of distance or range.

Two types of oscilloscope were built. One uses a 3-in. tube which has a circular sweep on which the signals appear as radial "pips." The other uses a 5-in. long-persistence screen tube which has a horizontal sweep on which the signals are vertical "pips." The long-persistence screen tends to average out the random noise and thus give a better signal-to-noise visibility.

The operation of the oscilloscope is, briefly, as follows: The transmitted pulse, by means of a separate synchronizing phototube, gives the oscilloscope a signal which starts the beam moving at a very high but known speed across the face of the tube. For example, this may be adjusted so that a 3-in. horizontal deflection represents a time of 10 microseconds or about 4910 ft range. This means that it takes 10 microseconds for the light pulse to travel 4910 ft to the object and return to the point of origin.

The received signal appears as a deflection (a small bump or "pip" on the circular or horizontal trace). The distance from the zero end of the trace to the point at which this signal appears is then a measure of the range. Owing to the persistence of vision the repeated signals give a steady trace on the screen. A calibrated scale on the face of the cathode-ray tube thus makes it possible to read the range directly. Knowing the range and the angle, which can be read from a calibrated scale on the mirror support, the elevation above the earth can be read almost instantly from a chart. Thus both range and elevation are available from one reading. Since the mirrors can be aimed in any direction it is not necessary to wait until clouds are directly overhead to make the measurement.

Aluminum Pallets

AN aluminum pallet, one third the weight of pallets made of other materials (36 lb against 100 lb), for use in handling goods where continued movement is involved, has been developed by the Reynolds Metal Company, Louisville 1, Ky. This lightness in weight results in a two-thirds cut on the shipping charges for the pallets themselves. They permit the advantages of unit-load handling to be extended to shipments over freight and truck lines. They are also claimed to be of value in making subsequent movements through warehouse to jobbers and to the large retailer, if the material is not too long inactive.

Made of newly developed high-strength aluminum alloys, these pallets are said to have withstood loads up to 26,000 lb without damage. Overload tests revealed no functional disorder right up to the point of actual destruction.

A typical design employs an upper deck made of two sheets of 52S $^{3}/_{4}$ H aluminum-alloy stock, the top sheet being 0.051 in. thick and the bottom sheet 0.040 in. thick. These sheets carry square ribs formed in them, each rib being 0.5 in. deep and 1.0 in. wide. Ribs in the top sheet run crosswise while those in the lower sheet run lengthwise. Top and bottom sheets are spot-welded to one another.

Lower-deck or bottom stringers are 52S $^{1}/_{2}$ H alloy, 0.064 in. thick, formed into channels for added strength, with corners forming the framework joined by 45-deg butt welds. Stringers 4 in. wide provide adequate bearing surface for tiering almost any load. A $3^{3}/_{4}$-in. clearance between the upper and lower decks is provided by drawn aluminum cups which act as structural columns to form a strong assembly. Eight $2^{1}/_{2}$-in-diam cups made from 52S $^{3}/_{4}$ H alloy 0.051 in. thick are used as spacers at corners and mid-points.

A 6-in-diam cup of 52S $^{1}/_{2}$ H alloy 0.064 in. thick is used for the central column. The curved surface of the spacers also helps guide the truck forks into place when engaging the pallet.

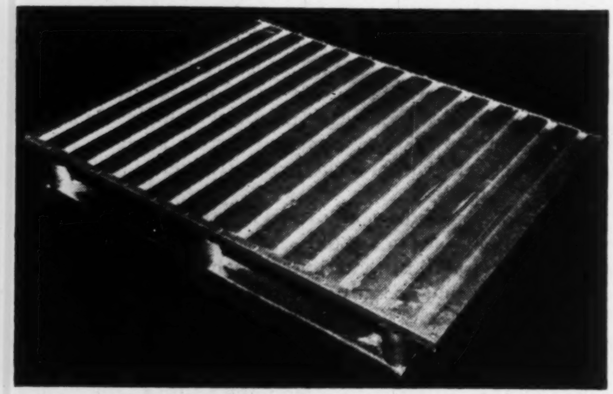

FIG. 4 VIEW SHOWING TOP OF ALUMINUM PALLET

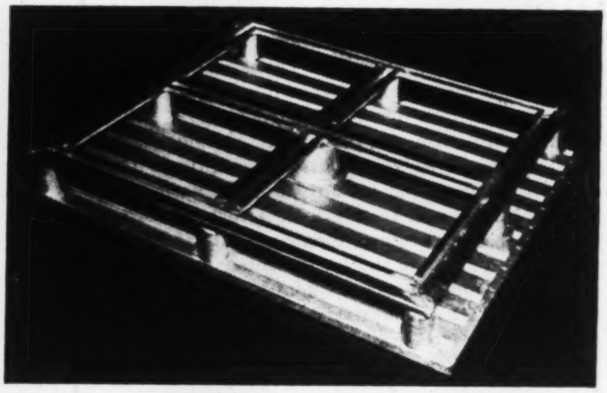

FIG. 5 VIEW SHOWING BOTTOM OF ALUMINUM PALLET

Aluminum pallets have many other advantages besides their lightness in weight, some of which are: They can impart no odors to their loads because they absorb none, being impervious to food smells, grease, or dirt; they present added safety factors since they are nonsparking and noncombustible; and even when badly worn, there are no splinters or sharp edges to form a hazard.

These pallets are so designed that the forks of the truck may enter the pallet from any one of the four sides or any of the four corners. This means that the pallet can be set down from one direction and picked up from another, affording added flexibility in stowing and removing loads. Less space is also required for maneuvering the truck since it need only make a 45-deg turn from an aisle to enter the pallet from the corner.

The pallet described is a standard 40 × 48 × $5^{3}/_{4}$-in. size employed widely in many industries. Other standard deck sizes include the 48 × 48-in., the 32 × 40-in., and the 42 × 50-in.

Stabilizing Dimensions by Deep Freezing

DIMENSIONAL stabilization by deep freeze has become a subject of vast importance, particularly in the manufacture of such precious parts as gage blocks, high-speed spindles, lead screws, dividing heads, all types of gages, and aircraft components such as fuel-injector pumps, that is, where any future growth of a part might result in rejects of vitally needed material and stopping a production line.

An article adapted from material provided by Gaston E. Marbaix, Ltd., in the Feb. 14, 1946, issue of *Machinery* (London, England) reveals the effects of subzero treatments on hardness and dimensional stability of precision parts, and outlines a test suggested by the the U. S. Bureau of Standards for determining the number of cold and heat cycles necessary to stabilize parts.

Any steel that retains austenite after heat-treating will increase in dimensions. Constant changes of climate and temperature cause the austenite to change to martensite. Martensite is of greater volume than austenite, hence no matter how accurately finished a part may be, it will change in dimensions.

The amount of growth cannot be predetermined because it is controlled by time, climate, temperature, and the amount of austenite retained. If the cycle of time, climate, and temperature is accelerated as in the case of an airplane or rapidly revolving spindle, the transformation is also accelerated and seizure of closely fitted parts is to be expected.

An experiment carried out for a well-known bearing manufacturer, whose product is used on every U. S. bomber and who was experiencing difficulty with growth due to the constant changes of climate and temperatures, best illustrates this point.

Ten standard hardened and ground bearings were measured on a comparator, then cycled six times from 212 F to minus 120 F, coming to room temperature between each cycle. The length of time at heat and cold was one hour. The results of this experiment were as outlined in Table 1.

TABLE 1 RESULTS OF DEEP-FREEZE TREATMENT OF TEN BEARINGS

Bearing no.	Hardness before, Rockwell C	Cycling size, in.	Hardness after, Rockwell C	Cycling size, in.	Dimensional change
1	63	0.8661	65	0.8669	0.0008
2	63	0.8661	65	0.8669	0.0008
3	63	0.8662	65	0.8669	0.0007
4	63	0.8662	65	0.8664	0.0002
5	63	0.8663	65	0.8665	0.0002
6	63	0.8662	65	0.8864	0.0002
7	63	0.8663	65	0.8665	0.0002
8	63	0.8661	66.5–67	0.8680	0.0019
9	63	0.8663	65	0.8663	No change
10	63	0.8661	66	0.8674	0.0013

It is to be noted that numbers 8 and 10 showed the greatest amount of growth and developed the greatest increases in hardness. Evidently, during the heat-treatment, bearings No. 8 and No. 10 had a tendency to retain considerably more austenite. Hence when the transformation occurred during the subzero temperatures, the higher increase in hardness was experienced, plus greater growth.

The higher hardness is explained by the fact that austenite is the soft part of steel, but when transformed to martensite becomes the hard part of steel. Further, tests on all ten of these bearings showed them to be stabilized to within 0.00002 in.

It is a well-known fact that in the manufacture of the original Johansson gage blocks in Sweden it took approximately six years to produce one block, and even then it did not possess a 100 per cent dimensional stability. After each grind the blocks were laid out of doors for about a year, and then a subsequent grind was given, until at the end of the sixth year it was ready for lapping.

Today a finer block than those original Johansson gage blocks is manufactured in less than 48 hours with a guaranteed accuracy of as little as two millionths of an inch, and a finish of 0.6 microinch rms by treating to minus 120 F in a deep-freeze unit.

High-speed spindles made of nickel carburizing steels after quenching have a tendency to retain austenite in the case. This results in a soft or spotty hardness condition. If then ground to size and assembled, these spindles often undergo sufficient transformation of the retained austenite to martensite to cause them to bind.

On steels such as high-carbon, high-chrome, nickel-carburizing, tungsten, and others that have a tendency to retain austenite after heat-treating, it is recommended that the following treatment be followed:

The part is frozen from two to six hours at minus 120 F. (If liquid is used in the freezer two hours is long enough, if frozen in air six hours will be necessary.) Then the part is allowed to warm to room temperature and subsequently heated to 200 to 250 F for two hours. This is repeated from 2 to 6 times, depending on the degree of stability desired.

It is important to have a knowledge of the steel as to its purity, since it has been found that a slight change in the sulphur content will definitely affect the stability of the steel. This can be corrected, however, by changing the time cycle or tempering cycle.

To determine the number of cycles of alternate cold and heat necessary to stabilize any part or parts the following test is suggested by the U. S. Bureau of Standards: (1) Not less than 36 to 60 parts hardened and finished to size are taken and numbered consecutively. (2) Hardness readings are taken and noted of each piece separately. (3) Each part is measured carefully and the sizes recorded. (4) The entire lot is divided into 6 groups. (5) Group no. 1 is subjected to one cycle of cold and heat (two hours at minus 120 F, to room temperature, two hours at heat 200 to 300 F.) (6) Group no. 2 is subjected to 2 such cycles; no. 3, to 3 cycles; no. 4, to 4 cycles; no. 5, to 5 cycles; and no. 6, to 6 cycles.

After the cycles are completed on all six groups, all parts are placed in boiling water containing 1 per cent of potassium dichromate to prevent corrosion. After boiling the parts for 24 hours, the parts are removed and allowed to cool to room temperature. The parts are then accurately measured, the amount of growth and hardness of each part being carefully noted.

If it is found that group no. 3 with three cycles of cold and heat shows the maximum growth, it can reasonably be assumed that three cycles will be sufficient to stabilize these parts.

Foreign Air Technical Documents

SOME 250 tons of German aeronautical documents which had been collected through the combined efforts of the Army Air Forces, U. S. Navy, and British Intelligence, are now being readied at Wright Field for dissemination to the aeronautical industry, research agencies, and educational institutions. This store of documentary material, consisting of about 500,000 items, has recently been moved from London to Wright Field, and the work of the Air Documents Research Center, A-2, United States Air Forces in Europe, been taken over by the Air Documents Division of Intelligence T-2, Air Materiel Command. So far, approximately 4000 documents have been processed for dissemination, and it is expected that by the end of this year about 55,000 documents considered to be of the most immediate value will have been catalogued. A card index containing approximately 20,000 cards cataloguing the documents already processed is now available for distribution.

Copies of the card index will be furnished free of charge to those agencies which will certify to an agreement to establish and maintain a complete catalogue card file. A list of locations of files available for reference to those agencies which are unable to maintain such a file will be supplied upon request. Microfilm copies of the processed German documents can be obtained by interested parties. The number of English translations of German documents is increasing gradually as each agency is requested to provide copies of its translations. The Air Documents Division is publishing bulletins informing participating agencies of all documents that have been translated or are in the process of translation so that duplication will be kept to a minimum. Entry will also be made on index cards as soon as the document has been translated.

In addition to the index cards, the Air Documents Division is preparing bibliographies on selected subjects and compiling a German-English dictionary, containing the latest aeronautical terms. To date, approximately 25,000 terms have been edited, and there will be about 45,000 terms in the published edition of the dictionary.

Close co-operation is maintained with the U. S. Navy and other government agencies in this endeavor. In the near future all declassified documents will be sent to the Publication Board of the Department of Commerce (see May, 1946, issue of MECHANICAL ENGINEERING, page 434) and will then be available from that office in printed form.

All communications concerning this material should be addressed to the Commanding General, Air Materiel Command, Wright Field, Dayton, Ohio, Attention: Air Documents Division, TSRED.

Stained Glass Windows

ACCORDING to an article in the May, 1946, *Industrial Bulletin* of Arthur D. Little, Inc., the building of many war memorials has resulted in a sizable demand for stained-glass windows. Already the studios that make them are operating at capacity and some have orders for several years ahead.

A beautiful window with muted rich colors and significant symbolism, creating a feeling of detachment from the everyday world, has a powerful emotional appeal. This appeal was recognized long ago, and as suitable glass became available, window making gradually developed into an art. The monk Theophilus, writing eight centuries ago, described the art of making stained-glass windows in every detail. Except for a few modernizations like the use of an electric soldering iron in place of a hand iron heated by a charcoal stove, his account still describes the present art well. Although it has had renascences and decadences, and has seen gradual developments in the glass used, the art has never been a "lost" one. The oldest known windows are those at the Cathedral of St. Julien at Le Mans, France, which date from the late 11th century. Some of the finest cathedral windows, mellowed by centuries of weathering, are at Poitiers and at Chartres, in France, but beautiful ones produced by contemporary artists may be seen in this country, especially in New York and Washington.

In a strict sense, neither the glass itself nor the picture it represents is what one admires, but rather, the light coming through the strong, prismatic colors. On dull days or in bright sunlight the colors are brilliant but without glare. A stained-glass window is a mosaic of translucent colored glass which is produced by adding metallic-oxide pigments to the molten glass. Light effects are achieved by the use of glass of "texture," with irregularities of color and thickness, modified transparency, or tiny bubbles. Some degree of detail in the design and control of light are secured with a black paint, made of powdered glass and mixed pigments, stippled on the colored glass, and baked into it.

Stained glass was formerly made only in Europe, but today the Blenko Glass Company of Milton, W. Va., also produces glass by the old manual "muff" process. When the original glass bubble has been blown and drawn into a cylinder, it is cooled, the ends cut off, and the cylinder opened up in a hot oven to make a sheet. Sometimes square bottles are blown and the side panels cut apart to give oblong pieces with the variations in thickness forming a sort of pattern.

In producing a window, the artist first makes a sketch and indicates the colors desired. Then a full-scale drawing or "cartoon" is made and from it the patterns produced for the individual pieces. After being cut to the pattern, each glass piece is glazed in the framework of the window by a tiny lead molding or "H" section, which is finally joined to the other leads by soldering. Before soldering, however, there is a rigid examination of the whole composition; pieces out of harmony are retouched with glass paint and fired, or entirely replaced.

The whole process is slow and expensive handwork, as befits an art. In one studio the average age of the personnel is 60, but returning veterans will shortly bring down this figure. It is a gratifying business for the few who have artistic or craftsmen's skills, combined with a love of color and symbolism, great patience, and the capacity for steady, creative work.

Portable Machine Shop

A TRUCK-MOUNTED repair shop designed for the use of contractors, utility and oil companies, mines, railroads, street-railway systems, highway departments, and concerns having mechanical equipment distributed over extended areas is being built by the Davey Compressor Company, Kent, Ohio, and is briefly described in the April, 1946, issue of *Machinery*. This unit, known as the "Davey Mobile Repair Shop," is suitable for mounting on any standard long-wheel-base truck. It contains virtually every item of equipment needed for mechanical repair and maintenance work.

While this mobile shop can be furnished with almost any desired combination of equipment, the manufacturer has worked out a number of standard assemblies for the use of specific operators. For example, one assembly includes as its main units a Davey 60-cu-ft compressor; a Lincoln 300-amp welding generator; a Westinghouse 5-kw power generator; a South Bend 14-in. lathe, with complete accessories and tools; and a drill press of 1-in. capacity.

Auxiliary accessories are the same as those found in any stationary machine shop. They include a blacksmith's forge and tools, two sets of fitter's equipment, a set of boilermaker's hand tools, a $^1/_2$-ton hoist, two 10-ton jacks, a hand-operated hoisting winch, plumber's tool kit, carpenter's tool kit, set of wood and steel drills, set of electrician's hand tools, a 30-cu-ft acetylene generator, gas-welding and cutting equipment, oxy-

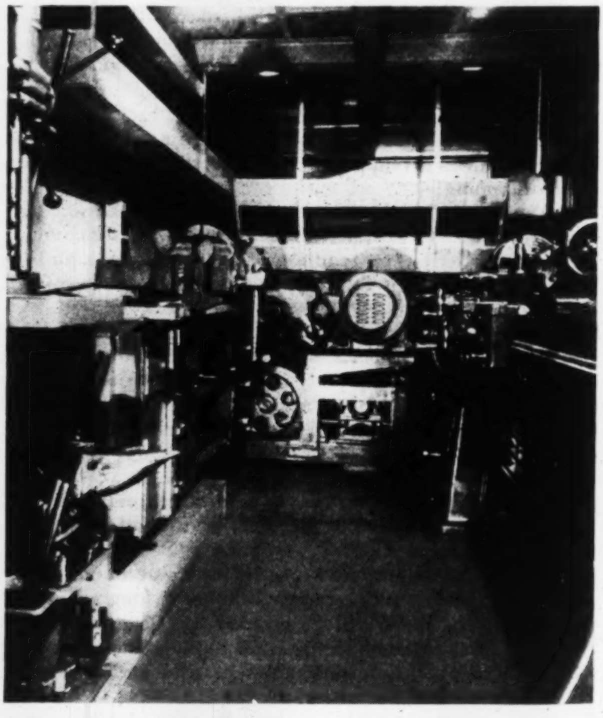

FIG. 6 VIEW SHOWING HOW EQUIPMENT IS ARRANGED TO PROVIDE ADEQUATE SPACE FOR SEVERAL WORKMEN

gen bottles, electric-welding accessories, grinder with drill-grinding attachment, pneumatic hand grinder, two pneumatic riveting hammers, two pneumatic hand drills, ax, pick, saw, soldering irons, emergency lights, air hose, shovel, etc.

The key unit of the entire assembly is the Davey split-propeller power take-off, which is inserted in the drive shaft of the truck to permit utilizing all the power of the truck engine for driving the air compressor, welding generator, and power generator. Its use eliminates the need for separate driving engines for each piece of equipment and permits mounting, on one truck, machines which, if individually driven, would require at least three trucks. This power take-off can easily be installed in any garage or service shop.

The truck body is replete with tool boxes and storage bins. An outside power receptacle is provided for local electric current when available. There are also seven inside power receptacles and five interior ceiling lights.

The lower third of the sides of the truck body can be lowered to a horizontal position, where they provide a large amount of outside workbench space. The upper two thirds of the body sides are raised to furnish protection against sun and rain for the men working outside the truck at the benches. The body is waterproof and can be locked to prevent tampering or theft.

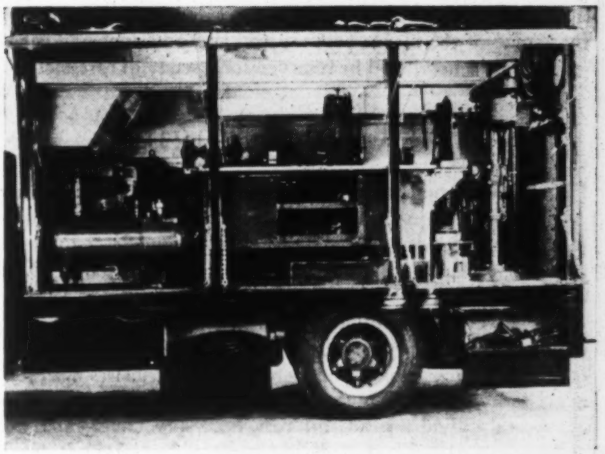

FIG. 7 PORTABLE TRUCK-MOUNTED MACHINE SHOP CONTAINING ALL THE EQUIPMENT COMMONLY FOUND IN CENTRAL REPAIR SHOPS

Rustproof Coating

A NEW rustproofing technique for steel and galvanized steel which deposits a coating of from 5 to 15 millionths of an inch (0.000005 to 0.000015 in.), will protect stock during manufacturing stages and permit a tighter bond with paints. Called the Banox process, and developed by Calgon, Inc., subsidiary of Hagan Corporation, Pittsburgh, Pa., the coating consists of a glassy metal phosphate, so plastic that it will bend with the steel or permit die-stamping without harm to the coating.

The process, described in the May 6, 1946, issue of *Steel*, was originally used for painted steel-shell containers during the war. Formerly, humid salt-laden atmosphere stripped paint along with vital identification from containers. Banox treatment was successful in overcoming this condition.

The chemical used is inorganic and insoluble and allows a considerable latitude in coating time by altering the working concentration. The process is operated at normal temperature and requires no heat to produce a simple, effective, and economical coating on steel, zinc, and other metals and alloys. Calgon states that good coatings have been produced in actual practice in as short a time as 10 sec at 80 F. As it relies on chemical rather than mechanical bonding, it holds organic finishes to metal with greater tenacity.

Banox treatment is said to accomplish four purposes: Preventing rust between cleaning and painting; insuring a grease- and alkali-free surface; increasing durability of finish as measured by outdoor exposure, salt spray, and other tests; and preventing spread of rust from unprotected edges where base metal is exposed.

Applied by spray, immersion, or brush, steel so coated resists rusting in plant atmosphere for as long as several months, thus affording temporary protection of units or assemblies before painting. Process surfaces are relatively nonporous.

The process requires no special equipment as the chemical is noncorrosive to tanks and applicators. Its simplicity and economy is derived from the low cost of chemicals per unit area of metal treated. As application is satisfactory at room temperature, no heating elements are necessary.

Chemical control of the process also is simple, as the treating solution may be replenished by addition of more compound or renewed at low cost. In large applications—as in primary production of treated steel—the process may be controlled by a simple rapid chemical test or by a check of the coating weight.

The process can be used by the steelmaker, by the converter, or final fabricator of consumer goods. This product was intended to improve the finishing of automobiles, refrigerators, gas and electric ranges, deep-freezing units, stokers, household appliances and the like.

Rare-Metals Research

FUNDAMENTAL research on so-called "rare metals" is urged by W. J. Kroll, consulting metallurgist, Albany, Ore., in an article in *Mining and Metallurgy*, May, 1946, to provide sufficient knowledge for future use.

In his summary Mr. Kroll says that rare metals have been dangerously neglected in this country, as can be seen from the recent foreign literature in which this subject is frequently treated. If two small firms had not taken up the task of making beryllium and copper-beryllium alloys in the years before this war, we would be in a very precarious condition today since beryllium copper is an important material for springs and for the construction of some airplane parts. There was no large-scale business in making beryllium copper and so the big companies repudiated it. It may be seen herefrom that rare metals may become strategic metals of prime order. Their investigation may contain surprises like that of the outstanding hardening of copper by beryllium and the boron effects in steels. Rare metals are strategic materials as can be seen from the great amount of work spent on them by German research during this war. A stockpile of knowledge has to be built up by investigating these metals and this would prove quite as important as to stock metals for the emergency of war. Special attention should be given first to the metals and alloys of barium, boron, titanium, zirconium, hafnium, thorium, uranium, cerium, yttrium, lanthanum, vanadium, columbium, gallium, and rhenium. The research work would have to be extended to the methods of extraction from the ores, to the separation from closely related elements, to the preparation of the elements in the degree of highest purity, to the making of master alloys, and to the study of all the physical and chemical properties of the metals and of their alloys. The knowledge of the properties will open the door for new uses. Risks will have to be taken. If the money incentive does not appeal to private initiative, the national interest should take over. It may be hoped that some of the means provided by the government for basic research in general will be reserved for a study of rare metals.

Air-Cooled Engine

THE development of a new air-cooled, internal-combustion engine, to be produced in two, four, and six-cylinder models, has been announced by Jack and Heintz Precision Industries, Inc., Cleveland, Ohio. It is designed to be largely fabricated of die-cast aluminum or magnesium alloys.

The six-cylinder engine, as are the others, is a horizontal opposed air-cooled type which incorporates slide valves in contrast with conventional poppet valves. It consists essentially of six individual aluminum or magnesium die castings, namely, crankcase, cylinder head, oil pan, accessory cover, and front and rear covers. The two crankcases are identical and actually consist of one bank of cylinders and half a crankcase. These two main castings are similar for all models, and are bolted together on the center-line of the crankshaft. Oil pans are available for either wet sump or dry sump and the accessory covers are available for all versions with different mounting pads for the accessories which are required.

Of special interest is the air-cooling system. The present system was developed for rear-engine installations although its location is of no consequence if sufficient openings are available for the entry and exit of the cooling air. Past history of air-cooled engines indicated that the use of a conventional direct-drive constant-speed-ratio fan is not adequate. The new design employed in this engine incorporates an axial-flow fan of die-cast aluminum which is belt-driven through a pair of variable-speed sheaves. The sheave at the fan is spring-loaded and changes in the fan-speed ratio are accomplished by a hydraulic servo which is actuated by engine-oil pressure. Wartime experience on aircraft engines indicated variations in absolute manifold pressure were practically a straight-line function of the variations in horsepower. This principle was utilized, together with an ambient-air compensator, to provide the control means for the hydraulic servo. This method of cooling provides relatively constant engine temperatures regardless of climate or power output.

Cold-Molded Plastics

THE art of cold-molding plastics merely requires that a charge of plastic compound be introduced to the mold cavity, compressed in a cold condition, and subsequently baked under oven or infrared heat. It is during this heating period that curing or polymerizing takes place and the product assumes its infusible shape.

An article in the May 23, 1946, issue of *American Machinist*, entitled "Plastics Are Molded Cold, Too," reveals this process as being the most rapid method of producing plastics. In fact, it can be done on a mechanical punch press at a rate of anywhere from 60 to 90 pieces per minute. Material and forming costs are low; the curing period is the major production cost. Tool cost is comparatively low because the mold cavity does not have to withstand long periods of heat, pressure, and acid reaction from the compound. Production from a cold mold runs anywhere from two to three times that of a conventional hot mold for this reason.

Molds are practically always of the positive type, and the part is raised above the cavity for easy handling. As the part is in an uncured state, resembling a preform for conventional molding, knockout pins cannot be used safely. If the part is raised above the cavity it can be easily handled without injury. However, ejection pads can be used for removing the part from the cavity, providing the pad area is large enough to prevent indentation of the part.

Because the life of a mold for the cold-molding process is long, there are more replaceable parts in the tool. These parts can be easily replaced and considerably extend the life of the unit, as the wear comes only from abrasion and pressure.

Small-lot production can be economically handled because of the low tool cost, which meets the needs of most shops requiring either electrical or control parts. In recent years considerable gains in mechanical strength have been obtained by using a synthetic resin instead of a natural resin such as pitchblende. With a resin, which is usually phenol formaldehyde, steam channels must be placed in the mold to hold the temperature slightly above that of the room, but well below the curing temperature. This does not slow the cycle but merely leaves the resin liquid.

Asbestos is the most commonly used filler, comprising about

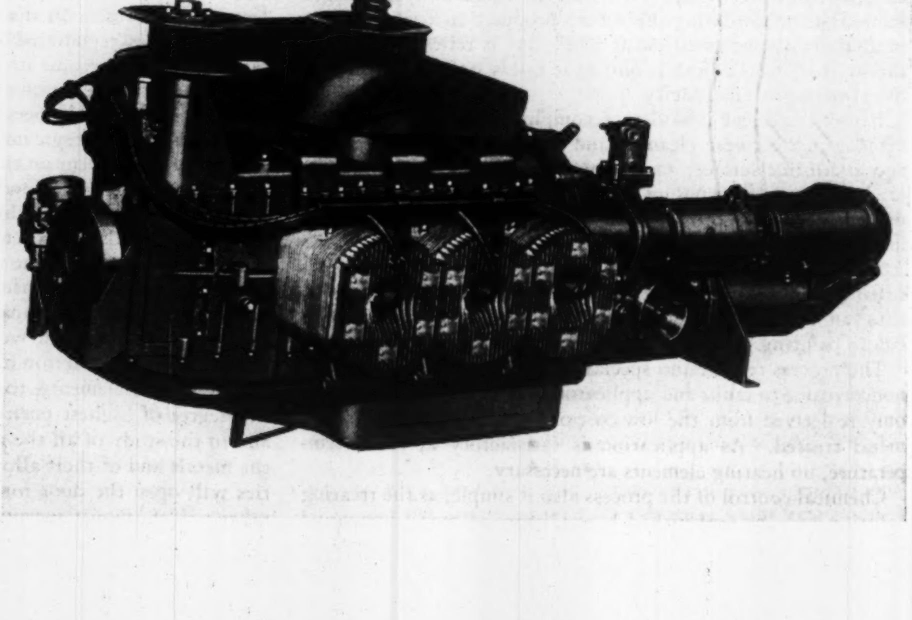

FIG. 8 SIX-CYLINDER, AIR-COOLED, AUTOMOTIVE ENGINE COMPLETE WITH CLUTCH, TRANSMISSION, DIFFERENTIAL, ROAD GOVERNOR, COOLING SYSTEM, AND STANDARD ACCESSORIES

70 to 80 per cent of the compound. The flow of the material is comparatively poor, and the compound must be carefully weighed and distributed throughout the cavity. Inserts can be easily loaded into the cavity, but usually require cementing or some means of rigid support because of the unequal and rapidly applied pressures.

Production is usually from single-cavity dies, or at most, two-cavity dies. On even the largest pieces pressure need be applied no more than 5 sec. After removal from the press the piece is subjected to oven heat, starting at 190 F to a maximum of 425 F. Phenolic cold-molded materials usually have tensile strengths of 3000 to 4000 psi, flexural strengths of 6000 to 7000 psi, and impact strengths of 0.15 to 0.16 lb per in. of notch. Mold shrinkage in the cold method usually runs about 0.006 to 0.008 in. per in. Phenolic resins, in liquid or powdered form, used in any specific cold-molding application must be chosen with care to achieve maximum desired qualities in the finished product. Such factors as type of equipment, pressure conditions, oven-curing facilities, and product characteristics determine the resin best suited for the purpose. The resin for original compounding should have high flow and good coverage.

Cavities may be chrome-plated, but this is done only where surface finish must be good and where the compound has high adhesive qualities. Interchangeable cavities may be used in the same mold block, which is fastened to the press platen. This decreases cost and increases economy.

Power Sources

A WELCOME diversion to the many and varied discussions of atomic power is offered by Edward Podolsky in an article, "Power Sources Other Than Atomic With Future Possibilities," in the February, 1946, issue of *Industry and Power*. He discusses applications of radio waves as well as the potentialities of volcanic steam and devices for harnessing the wind.

Radio-wave radiation has been used to heat rivets in construction work. Chemists have found that energy supplied by radio waves has proved useful in accelerating chemical reaction in much the same way that heat does. Furthermore, greater control can be maintained over chemical processes with radio waves. Also, chemists have discovered that radio waves can bring about chemical reactions which otherwise could not take place.

Radio waves are proving to be a source of power useful in baking and cooking. Four or five hours are required to cook a ham by steam; the ham losing as much as 10 per cent of its weight in the process. Knowing that the radio short waves have the ability to generate heat internally in objects to which they are applied, the radio division of the Westinghouse Electric Corporation tried them on a 14-lb ham. The ham was cooked to a delicate flavor in twenty minutes, with the loss of only half a pound in weight.

Recently a watch operated by radio waves was announced. Designed to operate without winding, the radio-powered timepiece, according to its inventor, presages the day when all clocks and watches will be controlled automatically by radio.

Not long ago the Baltimore and Ohio Railroad suffered considerable loss when insects began to destroy grains stored in freight cars. An engineer was consulted and short radio waves were used to eliminate the pests. The radiant energy killed the insects but did not affect the grain in the least. Since then, radio waves have found wide application for similar purposes as an efficient insecticide.

Engineers at the Russian Institute of Industrial Construction have found that ultra-short radio waves are capable of drying wet plaster walls in new building construction. A small transmitter is placed inside the space enclosed by the walls to be dried, and within a short time the radio waves produce sufficient heat within the plaster to dry it out. Drying is accomplished in a fraction of the usual time. In this way painting and other decorative work on the walls can be done with little delay, thus speeding up construction.

VOLCANOES

Living in the vicinity of a volcano is a hazardous business, but one compensating feature is that a volcano may be harnessed to furnish power just as a river is. People have lived in the vicinity of volcanoes for hundreds of years without thinking of putting this potential source of power to work. Near Ruscan Maremma, Italy, steam has been seen escaping at terrific pressures from the vents in the ground. Many such "geysers" are found in a volcanic area, and they consist of steam and gases with very little water. The steam is superheated as much as 50 C, and the gases issue from the ground at a pressure of about 14 psi.

In 1818 Francis de Larderel conceived the idea of using the erupted steam as a natural heating agent. He was the first to succeed in harnessing a volcano. But the credit must go to Prince Conti for tackling the problem of power from a volcano on a commercial scale. He actually drilled for the superheated steam as we drill for oil, keeping the hole full of water to hold back the latent powers of the volcano. Crews worked day and night until the warning rumble of the awakening power was heard. With this sound the men would take to their heels and place as great a distance between themselves and the volcano as possible. In a short time the rumble would change to an ear-splitting roar and shooting out of the hole would come the string of drilling tools, followed by a terrific jet of steam.

Several such volcano wells have been put to work. One of the largest was dug at Larderello (this installation is described, along with others, on pages 1175–1178 of the December, 1925, issue of MECHANICAL ENGINEERING), and several weeks elapsed before it could be harnessed. Some 440,000 lb of highly superheated steam is now being delivered each hour and is being put to good use.

Prince Conti had long been concerned with the wanton waste of volcanic power, and in 1904 made his pioneering attempt to do something about it. In that year he worked out a simple steam engine designed to operate by steam derived from volcanic jets. This engine was coupled with a small dynamo. But the steam contained highly corrosive gases and acids and these had to be extracted in order to prevent damage to the machine.

In 1912 Prince Conti abandoned the idea of steam cylinders because the low pressure of the steam after treatment made the cylinder size out of all reason where high power was concerned. Instead, he studied the application of turbines. To use the steam direct was again impractical, as the enormous volume of contained gas rendered the use of condensers impossible. Finally he decided to use the natural steam to heat pure water in special boilers, and eventually clean steam from pure water was passed over the low-pressure turbines.

In 1917 the plant at Larderello was providing 9000 kw, and in later years was increased. Today, other villages and towns near volcanoes are taking advantage of this source of power. Nearly 3000 kw are being generated at Castelnuova, Serrazzano, and Lago. These wells are now giving more than 2,000,000 lb of steam per hr, and as only a fraction of this is utilized for power purposes, enormous room for expansion is still available.

WIND

Another source of power that will be more fully utilized in coming years is the wind. Dr. Charles F. Brooks of Harvard

University predicts that the landscape of New England will be dotted by new-style windmills within a short time, furnishing power over high-voltage trunk lines to various industrial centers.

From early times men have harnessed the wind. Farmers on thousands of isolated farms have been using new-style wind generators to run their radios, turn their wheels, and furnish power for other tasks. But only recently technological improvements have made it possible to rely upon the wind as a constant source of electrical energy.

These modern windmills are of a radically new design. The windmill arms are of the "airfoil" type. The blades turn not so much from the drive of the wind against their faces, but from the pull of the partial vacuum over the backs of the blades. This type of windmill is already being used to supply part of the electrical needs of about 1,000,000 people in the United States.

The first windmill consisted of an apparatus in which wind was harnessed to an old automobile generator. In time, a 32-volt generator mounted above the farm on a steel tower was perfected. For the average farm a 32-volt set gives all the power needed to run separators, grinders, and ordinary household equipment such as a vacuum cleaner, radio, sewing machine, and electric iron. Operation is not intended for the electric range, refrigerator, or any machine requiring motors above one horsepower.

Dr. J. B. S. Haldane, famous English scientist, believes that the future will see greater use being made of power derived from the wind. He says: "The country will be covered with rows of metallic windmills, working electric motors which in turn supply current at a high voltage to great electric mains. Huge wind stations will be erected at suitable distances and during windy weather the surplus power will be used for electrolytic decomposition of water into oxygen and hydrogen."

Dr. Haldane's idea of using electricity to decompose water into oxygen and hydrogen is an attempt to solve the greatest remaining problem in the wind-generation of electrical energy—how power can be stored.

True, the wind does not always blow in most places, and equally obvious is that wind cannot be stored, nor can men wait for light and power until the wind does blow. For this reason some method must be used to accumulate power obtained on windy days for use when the air is still. Dr. Haldane suggests it might be done in the following manner: "These gases, oxygen and hydrogen, will be liquefied and stored in vast vacuum-jacketed reservoirs, probably sunk in the ground. In time of calm the gases will be recombined in explosion motors working dynamos which produce electrical energy once more, or, more probably, in oxidation cells. These huge reservoirs of liquefied gases will enable wind energy to be stored so that it can be expended for industry, transportation, heating, and lighting, as desired. The initial cost will be considerable, but the running expenses less than those of our present system."

Pressurized Airliner

GREAT Britain's first high-altitude pressurized airliner, the Avro Tudor 1, has completed an extensive series of tests in the course of which flights up to 30,000 ft have been made. These tests proved that the complicated pressurization installation was entirely satisfactory.

The new transatlantic-airliner will not now be buffeted by cross-currents that disturb the smooth flight of airplanes which travel through storm areas. It will climb above the weather into steady air. Flying at 20,000 ft and above, the thin air offers less resistance to the airplane's speed and also flight schedules will be more often completed.

Braille Gaging Instruments

IN order to aid blind persons in inspection work two British gage manufacturers have produced highly ingenious and extremely accurate instruments. One of these is the British N.S.F. Company, Limited, Keighley, Yorkshire, which has introduced a 10-in. vernier height gage and a 10-in. vernier caliper; the other is Messrs. Moore and Wright, Sheffield, who are manufacturing a Braille micrometer. A description of these unique gages as it appears in the May 23, 1946, issue of *The Iron Age*, follows:

The height gage and vernier caliper are of a direct-reading type, and although intended for the use of the blind, are so much easier to use than the standard vernier that they may well become popular with sighted workers. Increments of 1 in. are obtained by a spring-loaded pawl locating in slots accurately cut in the edge of the beam. The 1-in. intervals are subdivided

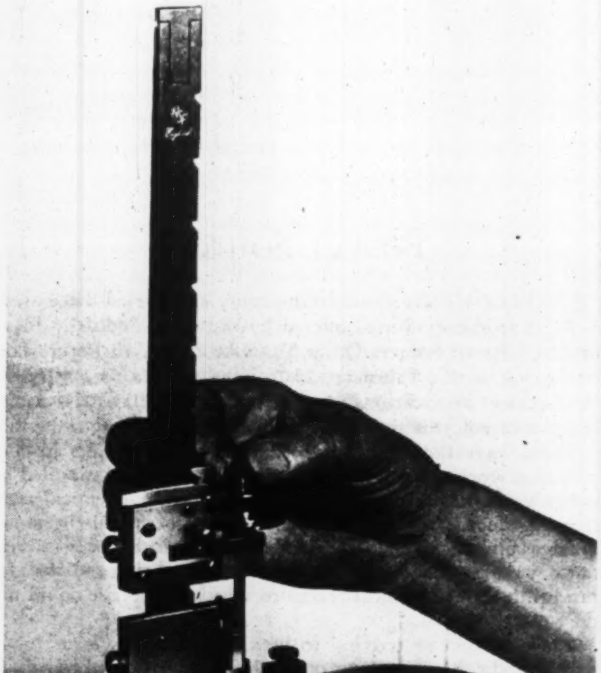

FIG. 9 BY MEANS OF THIS SPECIALLY DESIGNED VERNIER HEIGHT GAGE, BLIND INSPECTORS CAN OBTAIN EXACT MEASUREMENTS WITHOUT ANY FEAR OF ERROR

(The adjustable jaw slides on the beam and can be fixed at any point, the micrometer head also slides and is located by a pawl engaging inch slots.)

into increments of 0.100 in. by means of ten slip gages hardened and accurately lapped to size. These are pivoted to the saddle and spring-loaded so that they may be swung into line with the micrometer spindle as desired. Each tenth can be subdivided into increments of 0.025 in. by each complete turn of the micrometer screw, to which is attached a notched disk. This disk has 25 peripheral notches into which a spring pawl can click, thus enabling the micrometer screw to be moved in increments of 0.001 in.

To facilitate rapid settings, one of the 25 notches on this disk is made sufficiently deep to locate positively with a spring-loaded pawl so that it will be locked after each full revolution. This gives a definite indication of each full revolution of the micrometer screw. A knurled stem permits the pawl to be lifted to free the disk for additional turns.

When making a measurement the slip gages are swung out of line with the micrometer screw, which is turned back to its outer limit. The movable jaw or saddle is then closed until the workpiece is accepted with the conventional feel or degree of touch. The micrometer head is now moved down to bring the spindle into contact with the movable jaw, and immediately moved up again until its pawl enters the first slot in the beam that it encounters, whereupon it is locked by a thumbscrew. Next, as many slip gages as possible are swung into the space between the movable jaw and the micrometer spindle, each one being counted as it enters. Any remaining gap is closed by rotation of the micrometer screw, the number of complete rotations and the number of 0.001-in. increments needed to do this being counted.

The same procedure is followed with either the vernier caliper or the height gage, and it has been found that blind operators familiar with the normal vernier type of gage are able to learn to use these instruments successfully within an hour, without there being any doubt as to the accuracy of the reading associated with vernier instruments.

In the case of the micrometer, a series of three drums are attached to the spindle. The zero drum, which does not rotate, is placed between the other two and is held by a sliding rod to the frame of the instrument. The outer drum corresponds to the thousandths of an inch, and the inner one records the steps in $^1/_{40}$ in. By means of internal planetary gears the inner drum is geared to the outer so that each time the outer drum is given a complete revolution, which moves the spindle 0.025 in., the second drum is moved from one graduation to the next.

Complete revolution of the thimble (40ths of an inch) are thus read on the inner drum against the fixed zero, while partial revolutions, in terms of 0.001 in., are indicated by the outer drum.

In making a setting the anvils are closed on the work. The blind worker then reads by touch which graduation on the inner drum was the last to be in line with the zero mark; and which outer-drum graduation is in line with the fixed zero mark.

Similarly, if it is desired to set the instrument to a particular dimension, the outer or thimble drum is rotated until the inner-drum graduation, representing the number of 40ths, is in line with the zero mark; and then the correct outer-drum graduation, representing the balance in thousandths, is moved into line with the zero mark.

In addition to the zero graduation, further raised markings which constitute a vernier scale, are borne by the central fixed drum. In co-operation with the outer-drum graduations they can give readings to 0.0002 in., and a careful operator can easily read this scale to an accuracy of 0.0001 in.

Raised dots are employed to mark the graduations, with raised strokes to mark off groups of dots. Combined with Braille figures, this has been found ideal for reading by blind inspectors. The drums are made of light alloy and do not add appreciably to the over-all weight of the standard micrometer. They are available as units for converting existing micrometers to Braille instruments.

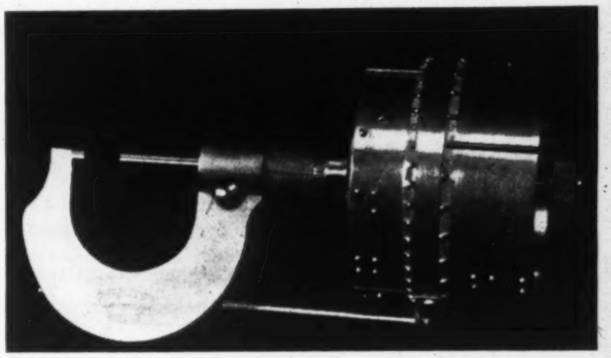

FIG. 10 SPECIAL BRAILLE MICROMETER EQUIPPED WITH A VERNIER SCALE BY WHICH AN EXPERIENCED BLIND INSPECTOR CAN READ TO THE NEAREST 0.0001 in.

Reports From Germany

German Rayon Industry

PLASTIC heddles, used in the loom harness at a German rayon-weaving plant during the war, proved to be a satisfactory substitute for the conventional steel heddles, according to a report released by the Office of the Publication Board, Department of Commerce, Washington, D. C. Six other reports on the German rayon industry were released at the same time.

The plastic heddles were found in use in the plant of Simon and Frohweir, weavers and finishers of worsted and spun-rayon fabrics, near Düsseldorf. The "Kreuzfaden-Walken," a loom attachment reported to increase pickage 10 to 12 per cent above normal, also was found in use at the plant. Confirmation of the increased efficiency of the attachment was obtained, according to the investigator.

The Kampf and Spindler plant at Düsseldorf is one of the few German rayon plants which is completely integrated. Kampf and Spindler spin, prepare, throw, and weave their own viscose yarn. Dyeing and finishing are done outside. They plan, however, to manufacture dresses for direct sale to retail stores.

Of special interest to American throwsters, according to the investigator, is the Hamel headless take-up machine, having three spindles in line, as compared with the two spindles in line in American machines. It increases output, in relation to floor space, by 100 to 150 per cent.

Methods and machinery were studied by the investigator in the "KUAG" plant near Muenchen-Gladbach. This throwing plant, according to the investigator, is interesting because of its use of up-twisters for winding the yarn upon a cone, and its ingenious conversion of special hollow-spindle up-twisters into combination up-twister and doubling machines. The methods and machinery used are described in the report.

The "Verseidag," a completely integrated rayon plant, is the largest producer in its field in Germany, according to the investigator. It is the result of a merger of many small weaving and finishing firms.

Two special finds at this plant were the equipment for printing day- and night-reading maps for German aviators and the novel warping and slashing methods.

At the J. P. Bemberg plant near Wuppertal an entirely new method of preparing cuprammonium rayon yarn for weaving was found.

This method has proved practical in weaving mills, according to the report. It involves continuous spinning and textile processing to spool, cone, or even slashed warp ready for weaving or knitting. It thus eliminates the six or seven separate operations in conventional production.

The "BARMAG" plant near Wuppertal was visited to examine the hollow spindle developed by the firm to produce crepe yarns by the double-twist principle.

The spindle, known in Germany as the "Doppel draht" spindle, runs at 8500 to 12,500 rpm, representing a twisting speed of 16,000 to 25,000 rpm.

The final report describes an automatic "stop-motion" for individual bobbins on the yarn-twisting frame. This device was found at the Lehrspinnerei at Denkendorf.

Water-Cooled Rotor Turbine

A novel water-cooled rotor turbine, capable of using normal materials at normal temperatures and at the same time utilizing high gas temperature for the turbine cycle, was developed by German researchers, according to a report released by the Office of the Publication Board, Department of Commerce.

The rotor is essentially a hollow drum with the blades attached radially. Holes drilled in the blades connect with the interior of the drum. The holes are blind at the blade tip. Water introduced into the rotor fills the blades and drum to a predetermined depth.

A slight density change in the water, caused by centrifugal force, results in circulation of the water. Circulation is initiated also by the high temperatures, which raise the water to a level where its specific heat is theoretically infinite. This permits considerable heat transfer for a very limited surface.

The water level is regulated by a bleed hole at each end of the drum. If the level drops, steam escapes. This reduces the pressure inside and permits the water to flow in by centrifugal action.

The report also contains brief descriptions of other research carried out at the Luftfahrtforschungsanstalt (Aviation Research Institute), including sections on fluid dynamics and materials research, turbine theory and design, and physical testing and development.

Ceramics

Use of ceramic and sintered materials in the production of high-heat-resistant turbine blades is one of many noteworthy developments in the German electrical and technical ceramic industry described in a report released by the Office of the Publication Board.

The possibility of using ceramics in gas turbines has been given much consideration in Germany, and extensive plans have been made for further development and evaluation, according to the investigator. Several of the problems encountered in this field are discussed in the report.

The Germans have made wide use of porcelain insulators for general utility work, in contrast to American use of glass and plastics, according to the report.

In the field of abrasives, the Germans have been working on production of cellular or bloated sintered alumina wheels, considered a promising development by the investigator. In his opinion, their methods have a possible application for production of highly refractory heat-insulating masses.

A special microhardness microscope, made by the Zeiss Company, Jena, is described in the report. A small diamond pyramid is embedded in the glass objective. In testing material for hardness, a weight is applied to the diamond point, and the indentation made by the material is measured by means of the optical system, having a magnification of 1000 times.

Among other German developments in the ceramics field are ceramic-organic plastic tapes of high dielectric constant, moldable mica products, sintered boron carbide, and a porous filter medium for a wide variety of applications.

The report presents the results of investigation of 16 German research and manufacturing organizations. Production methods, formulas, bibliographies, and other pertinent data are included.

New Silver Polishing Process

THE accidental use of a silver-plated wire in cleaning phosphor bronze electrolytically has given birth to a new polishing process. Credit for developing the novel electro-polishing method goes to Dennis R. Turner, physicist in the electronics department of the Research Laboratories of the Westinghouse Electric Corporation.

Cyanide was the chief factor in the chance happening that led to the discovery. Mr. Turner had added that compound to an electrocleaning solution when dime-size phosphor-bronze diaphragms for microwave tubes proved particularly difficult to wash. One of the diaphragms had been suspended in the bath, through which alternating current was passing, by a strand of wire previously used to immerse some object being silver-plated. The wire was a dull-white in appearance as silver plate always is before being polished. But when the phosphor-bronze diaphragm was lifted out of the solution the piece of wire had taken on a high luster.

Metal articles to be silver-plated are immersed in a bath of silver-cyanide plating solution and negative current sent through, causing a deposit of pure silver upon the objects. When they are removed from the bath, they are evenly plated with silver but are white and lusterless. They must be buffed by hand on a revolving wheel treated with some sort of buffing compound to impart the necessary shine. Buffing not only entails an extra handling of every piece but the loss of a certain proportion of the silver through abrasion.

With the new method, the silver-plated object is immersed in a bath of silver-cyanide solution normal to the regular plating operation. Instead of sending negative current through the bath as in plating, however, positive current is applied in about four times the amperage used to plate the metal, but not continuously. The positive energy is applied for a few seconds, discontinued, then sent through again, and this intermittent action repeated for several cycles. When the article has reached its peak of luster, it is taken out of the bath, rinsed, and dried. The entire operation takes little more than a minute.

So that the current might be applied and interrupted at proper and regular intervals, Mr. Turner connected a small motor with a switch that opens and closes a contactor to send along the intermittent flow of energy.

Although this electrolytic polish can be effected just as well by employing a plain cyanide solution, the more practical way is to utilize the same silver cyanide bath used to plate the objects, rather than having to transfer them to another tank containing only cyanide.

Ideal industrial practice would be to immerse the metal pieces—many at a time—send through negative current to silver-plate them, then intermittent positive charges to attain the bright finish—all in the same bath. Besides eliminating the whole buffing process, this procedure would have the advantage of retaining right in the original solution the small quantity of silver removed by the electrolytic action of the cyanide while polishing.

The new method has been so successful that it is being used in the Westinghouse Research Laboratories to polish silvered contactors, items of switchgear, microwave apparatus, radar sets, and other devices needed in experimental work. For many years heretofore buffing has been the standard treatment.

This electropolishing process unquestionably possesses the benefits of saving time, labor, and material. Tests are now being conducted that may show, also, that the bright finish imparted to plated silver by this method is definitely superior in brilliance, wearing qualities, and tarnish resistance compared to the polish given by mechanical buffing.

Productive Power Exhibit

ADDRESSING the Edison Electrical Institute's conference at the Waldorf-Astoria Hotel, New York, N. Y., on June 4, 1946, C. B. Stainback, manager of the Westinghouse Electric Corporation's Industrial Department, listed seven techniques in introducing a "Productive Power" exhibit which is soon to tour the nation to help industry solve many of its production problems.

Adequate wiring, according to Mr. Stainback, is most pressing of all needs. Approximately 90 million dollars' worth of wiring facilities should be installed in American factories to modernize existing facilities for most efficient production. Lighting fixtures and lamps will add another 65 million dollars; air cleaning with the Precipitron and air conditioning, 25 million; radio frequency heating, 20 million; and resistance-welding equipment, furnace brazing equipment, and infrared heating, 39 million more.

The electrical industry is satisfied, Mr. Stainback pointed out, that sustaining and improving our standard of living is dependent on continued increase in the utilization of electric power in industry. Productive Power is a contribution to this nation-wide effort to promote the further electrification of American industry.

It is a traveling forum that will bring to countless American people for the first time a cross section of a modern industrial plant demonstrating the actual operation of highly developed electrical processes largely responsible for the high standard of living they enjoy.

Tomlinson Fort, member A.S.M.E., manager of Westinghouse's central-station sales, declared that installation of these seven electrical processes along with lesser warborn developments would increase by 27 per cent the amount of horsepower at the command of each worker over the amount at his disposal during the height of the war production.

J. M. McKibbin, Westinghouse assistant to the vice-president who directed the Productive Power show, declared that manufacturers will be extremely dependent in the future upon all types of electrical devices in order to meet successfully the challenge of survival and growth. This program has been prepared to help manufacturers thoroughly analyze their problems and adopt most efficient methods to meet their specific needs. Productive Power covers seven applications for electric power in industry.

The first deals with adequate wiring. A scale-model factory layout is used to demonstrate the advantages of better wiring, power-factor correction, and the application of circuit breakers.

Section two deals with resistance welding. Here the advantages of resistance welders equipped with electronic controls is demonstrated by testing actual welds in a tensile tester.

Third, lighting, illustrates the problems of shadow, direct glare, and reflected glare with the proper steps for correction. Other demonstrations show the importance of adequate quantity, proper distribution, and good maintenance.

Fourth, electric-furnace brazing, demonstrates by means of an animated sound slide film how simple capillary action has made mass production brazing possible. Then with actual samples, the results of electric-furnace brazing in industry are reported.

Fifth, infrared drying, dispels the mysteries of infrared and demonstrates and compares the drying time and efficiency of forced air, heated air, and infrared.

Sixth, radio-frequency heating, shows the speed and selectivity of induction heating by use of an induction generator. This section of the program will be primarily a laboratory session on industrial heating problems.

Seven, air handling and conditioning, introduces case histories to prove how air can be put to work in industry. Then with actual equipment the air-cleaning efficiencies of mechanical and electrical air cleaners are compared.

The Productive Power Show shortly will go on a nation-wide tour lasting approximately a year. It will be exhibited in most of the industrial cities in the UnitedStates.

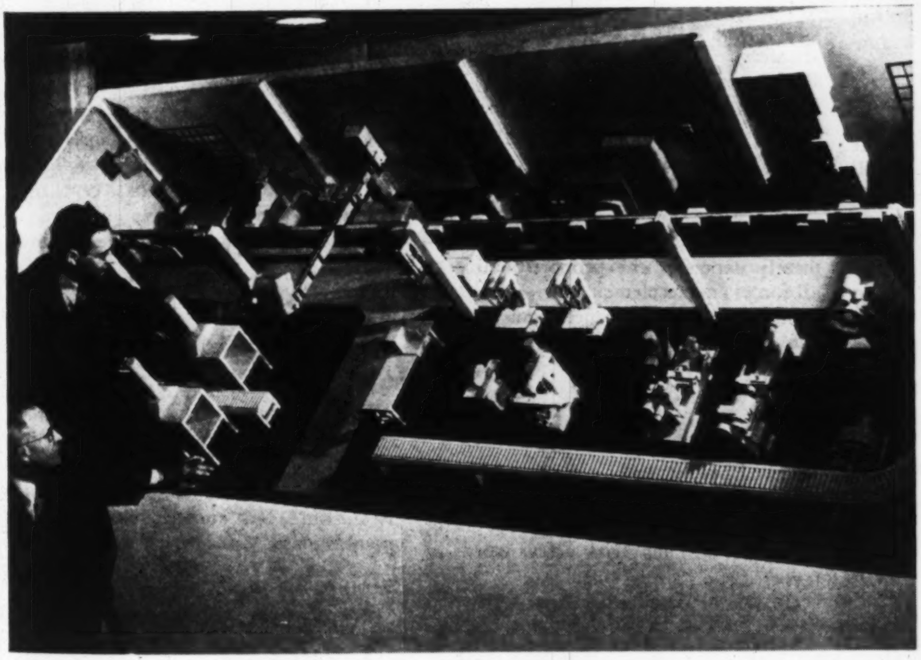

FIG. 11 THREE-DIMENSIONAL PLANNING

(Scale model of typical modern factory used to demonstrate advantages of adequate wiring, power factor correction, and circuit protection in the Productive Power show. Viewing layout are, *lower*, J. L. Wagoner and, *upper*, R. W. Mallick, member A.S.M.E.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

The Technical Man—Capital's Last Line of Defense

To the Editor:

If a kid from high school can pay \$50 to a union and get a \$250 per month job, where is the logic in spending \$2000 and four years for a college education to land a \$125 per month job? Large and small industrial and manufacturing concerns are unwittingly showing there is no reward for ambition. Salary for designers and men of technical responsibility is sometimes less than one half of that paid to bricklayers by the same company.

The fact that a man gives four to six years to get an above-the-average exposure to technical education makes him a candidate for management's team. His desires and goals are based on a belief in the free-enterprise system—everything management could want. Why must he be insulted as a "college upstart," "brain boy," or "pencil pusher?" Managements say they have to break him in. How long? One year, five years, ten years? It is absurd that good technical men after five or six years with a company are getting less than operators, maintenance, or construction laborers do after six months.

Managements must wake up to the fact that, if necessary, these men will shake their bonds of "professionalism" and band together in a stronger group than CIO, AFL, or the medical profession ever dreamed of. Capital must wake to the idea that good men are being drawn away from technical skills because the reward for education is all too often a negative quantity.

More than the loss of potential technical men is the loss of already trained men turning to the government for a career. If the Army goes through with its technical training program, each year a larger number of young technicians, sympathetic to government control and bureau systems, will emerge. These will be added to those already in Civil Service under the departments of Interior, Commerce, and Agriculture.

Still not bothered? Does it ever occur to management that the projects of MVA, St. Lawrence Water Way, and many uneconomical, unjustified others are schemes dreamed up to make work for the organization—to justify its survival or existence? There will be no end of their collective imaginations once the organization has more men to make "dreaming up projects" their career.

The technical man today, because of his pride in traditional professionalism, stands as the last bulwark between management and labor. Let him get organized against management and there will be no management. General Motors claimed that if foremen organized the company would do without foremen. But pity the poor company that cannot count on its technical men!! Pity poor companies that are forced to pay taxes to support its own competition from government-paid departments that do not need profits to stay in existence.

Because of management's everlasting shortsighted policy, technical groups got salary adjustments only after organized labor forced them. With few exceptions every technical man owes his salary raise to the labor union in his company. Management cannot hope to retain the respect and loyalty of technical groups with these tactics, and, without the professional man's loyalty, management—as such—is through.

Bill Maddock.[1]

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[1] Benton Harbor, Mich. Junior A.S.M.E.

Alice and the Sluggers

To the Editor:

I have read with delight and with hearty approval the recent article by Messrs. Hawkins and Sanford Moss,[2] concerning Alice's adventure with the sluggers. This confusion, over "slugs," "poundals," and "gee-pounds," has been plaguing mechanical engineers for 20 years. I suggest that the simple equation $\left(F = \frac{m}{g} a\right)$ be simplified even further by being written $F = m \times \frac{a}{g}$ which merely expresses the proportionality of all forces and accelerations.

I hope that coming generations will dispense with slugs, poundals, and gee-pounds completely.

Robert E. Bruckner.[3]

To the Editor:

Being suspect as a slugger myself, I have not much to lose in the eyes of Alice, Jr.; so I may risk a few words in favor of the "slimy slug."

If Alice's "Wonderland " were situated so high above the clouds of her sleepiness that the gravitational acceleration were just 1 ft/sec^2, the air would be too thin for sluggers and Alice could claim

$$1\ \text{lb}_{\text{force}} = 1\ \text{lb}_{\text{mass}} \times 1\ \text{ft/sec}^2$$

without meeting any arguments; the Wonderland's lb_{force}, however, being what Alice's countrymen call "poundal."

Down on this earth, scientists and engineers agreed to define any basic units by equations of that type; for instance

1 dyne = 1 gram × 1 cm/sec^2
1 gram = 1 poise × 1 cm × 1 sec., defining the poise
1 volt = 1 amp × 1 ohm
1 watt = 1 volt × 1 amp
1 farad = 1 ampere-second/1 volt

So, why write

$$1\ \text{lb}_{\text{force}} = 1\ \text{lb}_{\text{mass}} \times 32\ \text{ft/sec}^2$$

instead of using the name "slug," which is nothing but another word for "32 pounds mass,"[4] and writing

$$1\ \text{lb}_{\text{force}} = 1\ \text{slug} \times 1\ \text{ft/sec}^2$$

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[2] "Alice and the Sluggers," by L. A. Hawkins and S. A. Moss, Mechanical Engineering, vol. 68, 1946, pp. 143–144.

[3] Consulting Technical Engineer—Product Engineer; address, Box 45, Upper Montclair, N. J. Member A.S.M.E.

[4] The value 32 is used for simplification instead of the standard number 32.1740. Incidentally, not having a word like slug for 9.81 kg_{mass} is not an advantage, as Alice means, but rather one of the disadvantages of the metric system, as compared with the British gravitational system.

where the subscript "force" can be left out.

However, the former equation can be used as well. It is only necessary not to forget the subscripts "force" and "mass" (or, say, *f* and *m*) and the dimensionless number 32.

Eventually having taken sides for lb_{mass} will not help Alice, since she will either have to act as indicated in the last paragraph or use the equation

$$1 \text{ poundal} = 1 \text{ lb}_{\text{mass}} \times 1 \text{ ft/sec}^2$$

which neither the sluggers nor the pounders seem to like.

That's all and perfectly well known to the gracious sponsors of Alice. I am afraid that their most amusing dialogue, in addition to its wholesome effect of making people laugh, will have the regrettable secondary effect to further becloud the meaning of the "slug" in the eyes of such readers to whom it was not clear before.

MAX JAKOB.[5]

TO THE EDITOR:

Publication of the article on slugs by Messrs. Hawkins and Moss is a welcome service to those of us who use dynamics and must express their conclusions to the satisfcation of others, some of whom have objected to the use of pounds-mass. Most of us work, I believe, freely and informally with the pound-mass and the pound-force, as in saying that a 150 lb pilot is a 750 lb load at 5 *g* acceleration. That is, 750 = 150 × 5. When it comes to presenting such data formally we are caught in the meshes spun by textbooks which seem to have been intended for stress work only.

The good humor with which the authors present their case will, I hope, help in promoting their purpose. It seems that drilling slugs into the heads of students has left many with permanent scars which result in expressions of pain and anger whenever this point is touched.

I would like to go one step further in adapting the symbols of formal presentation to the easy methods of informal calculations, by removing the denominator "*g*" from under the mass (or weight) and writing it under the acceleration, which then will be expressed in the convenient, easily imagined, and now common terms of standard *g*.

Then one *g* is the standard acceleration of gravity. Any acceleration is expressed in terms of the standard *g* by dividing the number which expresses it (in any units) by the number which expresses the standard acceleration of gravity (in these same units). This latter is the g_c of "Alice and the Sluggers." Then the computation is made in the form

$$F = m\,(a/g_c)$$

with g_c as a pure number. The (a/g_c) gives the commonly used expression of a given acceleration *a* in terms of the standard acceleration *g*. Complete freedom in the choice of basic units results from this procedure. We have for instance the following approximate expressions

$16 \text{ ft/sec}^2 = 0.5 \text{ g} \quad (16/32 = 0.5)$
$1962 \text{ cm/sec}^2 = 2 \text{ g} \quad (1962/981 = 2)$
$1930 \text{ in./sec}^2 = 5 \text{ g} \quad (1930/386 = 5)$
$15 \text{ mph/sec} = 0.68 \text{ g} \quad (15/22 = 0.68)$

The effect of 5 *g* or of 0.5 *g* is much more easily visualized without further conversions than the effect of 1930 in./sec² or of 16 ft/sec² and this gives an additional safeguard against errors.
The numerical equations are then

Force (pounds) = mass (pounds) × acceleration (in terms of standard *g*)

750 lbs (force) = 150 lb (mass) × 5 (in terms of standard *g*)

in line with common use in conversation. The same procedure can of course be used with tons or kilograms. It must be remembered that only the 5 of an acceleration commonly called 5 *g*, appears in the equation and that it has the dimensions of acceleration.

I find by experience that this conversational method is the easiest to use in all sorts of calculations and automatically avoids mistakes caused by mixed units, such as miles per hour for speed and feet per second per second for acceleration. Just like many other engineers I use this method to calculate brake reactions, unbalance forces, comfort factors, etc. Some of my very learned confreres frown upon it as if it were an illegitimate offspring of applied science and will probably continue to do so until the method is made legitimate and respectable by use in textbooks and authoritative publications.

HENRY O. FUCHS.[6]

TO THE EDITOR:

There is perpetuated upon students and practictioners of science an unnecessary state of confusion about the so-called gravitational constant *g*. The confusion arises from the fact that one symbol *g* sometimes has two different physical meanings. This circumstance alone would naturally cause trouble; but it is made even more confusing by the frequent lack of explanation about the facts.

Two symbols should be commonly used instead of *g* alone. The earth's gravitational "constant," namely, the acceleration caused by force from the earth's gravitational attraction can logically retain the symbol *g*. Its numerical value differs from point to point on the surface of the earth and with altitude above it.

An additional constant also exists however, whose value is the same everywhere in the universe, and to which the same symbol *g* is customarily applied. The identity of this constant is rarely clarified in textbooks, rarely mentioned in literature references to *g*, and many people do not realize that it exists. Without it Newton's Second Law which states that acceleration is ***proportional to*** the ratio of force to mass, is dimensionally incomplete.

This law of Newton is almost invariably written

$$F = ma \ldots\ldots\ldots\ldots\ldots [1]$$

$$\text{Force} = \text{mass} \times \text{acceleration}$$

The dimensions in the foot-second-pound *force* system are

$$\text{lb} = (\text{mass units}) \times \text{ft/sec}^2$$

Obviously, a conversion from pounds-force to mass units is missing.

To make a statement of Newton's Second Law dimensionally homogeneous, it is necessary to include a dimensional constant which we shall term g_c. Its dimensions are

$$\frac{\text{ft}}{\text{sec}^2}\Big/\frac{\text{force unit}}{\text{mass unit}}$$

Thus

$$F = ma/g_c \ldots\ldots\ldots\ldots\ldots [2]$$

$$\text{lb } \textit{force} = \frac{(\text{mass unit})\text{ ft}}{\text{sec}^2}\Bigg/\frac{(\text{mass unit})\text{ ft}}{\text{lb } \textit{force}\text{ sec}^2}$$

$$\text{lb } \textit{force} = \text{lb } \textit{force}$$

When the force is caused by the earth's gravitational attraction, the resulting acceleration is assigned the symbol *g*; and the equation becomes

$$W = Mg/g_c \ldots\ldots\ldots\ldots\ldots [3]$$

$$\text{lb } \textbf{\textit{weight}} = \frac{(\text{mass unit})\text{ ft}}{\text{sec}^2}\Bigg/\frac{(\text{mass unit})\text{ ft}}{\text{lb } \textit{force}\text{ sec}^2}$$

$$\text{lb } \textbf{\textit{weight}} = \text{lb } \textit{force}$$

The numerical value of the constant g_c depends upon the mass units which are selected. If we select as a unit that mass (quantity of matter) which weighs 1 lb *force*, at some standard spot on the face of the earth (where $g = 32.1740$ ft/sec^2), then the universal constant g_c assumes the value

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[5] Research Professor of Mechanical Engineering, Illinois Institute of Technology; Consultant on Heat Research, Armour Research Foundation, Chicago, Ill.; Nonresident Research Professor of Heat Transfer, Purdue University. Mem. A.S.M.E.

[6] Preco, Inc., Los Angeles, Calif. Mem. A.S.M.E.

$$32.1740 \frac{\text{lb } mass}{\text{lb } force} \times \frac{\text{ft}}{\text{sec}^2}$$

Equation [3] in numerical terms for a "standard location on the earth" becomes

$$1 \text{ lb } weight = 1 \times 32.1740/32.1740 \text{ lb } force$$

Elsewhere, 1 lb *mass* will no longer weigh 1 lb *force*, since gravity will no longer cause an acceleration of 32.1740 ft/sec^2.

If the slug be used as the unit of mass (an obsolescent practice),[7] the conversion factor g_c assumes the value 1.0000 $\frac{\text{slug}}{\text{lb}} \times \frac{\text{ft}}{\text{sec}^2}$. Now Equation [3] of this comment, can be assigned numerical values as follows; at a "standard location"

$$32.1740 \text{ lb } weight = 1 \times 32.1740/1.0000 \text{ lb } force$$

The value 32.1740 is still a universal ratio, however, which relates slugs *mass* to pounds *mass*. Different from g, the acceleration caused by gravity, it is the same everywhere in the universe.

We shall state as a definition of this constant: "The inertial constant g_c is the acceleration which results when one unit of force is applied to one unit of mass." Its value everywhere in the universe is

$$32.1740 \frac{\text{ft}}{\text{sec.}^2} \bigg/ \frac{\text{lb } force}{\text{lb } mass}$$

WINFIELD B. HEINZ.[8]

TO THE EDITOR:

May I extend my appreciation to your editorial staff and to Messrs. Hawkins and Moss for their discussion of "Alice and the Sluggers" appearing on page 143 of the February issue of MECHANICAL ENGINEERING. I have a good deal of the same feeling as the authors in this insistence on the use of the acceleration equation, $F = ma$, without a constant, necessitating an inconvenient unit of mass; in fact, inconvenient *units* of mass because the unit would have to change as we change the units of force or acceleration. There certainly seems to be no good reason why we cannot write $F = Cma$, choosing the constant C to suit the other units. The "slug" is usually defined for acceleration in ft/sec^2. It is customary in heat transfer to use for the unit of time "hour" instead of "second." However the unit of mass of a slug defined as above is generally still used, giving us the employment, really, of two different units of time, sometimes in the same equation. This leaves me feeling a good deal like Alice, Jr.

R. E. ORTON.[9]

AUTHORS' CLOSURE

Larry Hawkins and I are greatly pleased at the reception of our engineering adventure into whimsy. The letters of Messrs. Bruckner, Fuchs, Heinz, Jakob, and Orton, as well as some personal communications, convince us that Alice was right and that the slug is an unnecessary nuisance that easily can be eliminated. Mr. Fuchs well remarks: "It seems that drilling slugs into the heads of students has left many with permanent scars which result in expressions of pain and anger whenever this point is touched." Even the self-declared slugger, the learned Dr. Jakob, admits that it is possible to "further becloud the meaning of the slug in the eyes of such readers to whom it was not clear before." Of course, the reason for the permanent scars and beclouding is the fact that, as Alice points out, pounds-mass and pounds-force have been well known to everybody and are legal as well as popular concepts. Furthermore, we do not believe, as Dr. Jakob writes, that scientists and engineers agree to define any basic units by equations with unity as a proportionality factor. So Alice is right when she says 32 is a perfectly good proportionality factor. We agree with Mr. Fuchs that this dimensionless proportionality factor, g_c, can with advantage be made the divisor of the acceleration. This has the advantage that he points out, that when an acceleration is expressed in terms of standard g by dividing by g_c, so as to give the now very common expression such as "acceleration of $5g$," it is more easily visualized than when given in feet per second^{-2} or the like.

The discussion of Mr. Heinz seems to have been originally written for another purpose. However, in the main the ideas of Mr. Heinz are consistent with those of Alice. Alice will agree with Mr. Heinz that there are at least two values of gravitational acceleration. One is the local value existing at every point on the earth's surface, which is sometimes called g_L. Another value is an arbitrarily selected standard value of the earth's gravitational acceleration $g_0 = 32.1740$, which for all practical purposes is close enough to the local value at any point to be used instead of it. Both g_L and g_0 definitely are accelerations and have the dimensions of acceleration. There is a third value, g_c, which, as Mr. Heinz well states, is necessary because Newton's Second Law is that acceleration is proportional to the ratio of force to mass. Our only difference of opinion with Mr. Heinz is the dimensions of g_c in terms of the fundamental dimensions L, M, and T. Newton's Law can be written as Mr. Heinz says, either as $F = ma$, or $F = ma/g_c$. In both of these equations F, m, and a will have the same dimensions. It seems to us that it follows that g_c is a pure number, or is, as Mr. Heinz mentioned, in agreement with Bridgeman, a dimensional constant. Such a number also has been called a number with zero dimensions. Mr. Heinz has pointed out to us in correspondence that g_c should not be called a dimensionless number because the numbers which are usually given this name, such as Reynolds Number and Mach Number, are independent of units, whereas g_c does depend upon units in which force, mass, and acceleration are expressed. So, instead of calling g_c a dimensionless number, we think it is proper to call it a pure number, or a number without dimensions.

SANFORD A. MOSS L. A. HAWKINS.

Lock Nuts

TO THE EDITOR:

Since the establishment of "Briefing the Record" in MECHANICAL ENGINEERING, I have read with interest the items as a good source of information on current developments.

I wish, however, to take friendly issue with part of the opening statement in "Lock Nuts" on page 356 of the April, 1946, issue: ". . . . scientific workers have failed to analyze the causes that make nuts come loose."

It seems to me that credit should be given to the theory and its experimental support of the loosening of nuts in the paper by Goodier and Sweeney, "Loosening by Vibration of Threaded Fastenings" in MECHANICAL ENGINEERING for December, 1945.

I feel that, in the light of the Goodier and Sweeney paper, the statement referred to in the April issue of MECHANICAL ENGINEERING is somewhat misleading.

PAUL H. BLACK.[10]

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[7] "Thermodynamic Properties of Air," by . H. Keenan and J. Kaye, John Wiley & Sons, Inc., New York, N. Y., 1945.

[8] Consulting Engineer, Bound Brook, N. J. Mem. A.S.M.E.

[9] Mall Tool Co., Chicago, Ill. Mem. A.S.M.E.

[10] Associate Professor of Machine Design, Cornell University, Ithaca, N. Y. Member A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Profitable Labor Relations

Reviewed by William H. Kushnick[1]

Profitable Labor Relations and How to Develop Them. By Paul Mooney. Harper & Brothers, New York, N. Y., 1946. Cloth, $5^1/_4 \times 8$ in., 209 pp., $2.50.

THESE very readable 200 pages are worthy of the attention of supervisors, executives, and personnel men. Even though much of what the author presents is not particularly new in philosophy or technic, nevertheless the principles and practices advocated therein are keystones to sound labor relationships.

This book does not deal with bargaining or any of the features of a union contract; it confines itself entirely to a constructive program of personnel development. Such a program is a necessary activity in every company and is a must for those which are unionized. Management often expends all of its efforts in the language and construction of a union agreement, overlooking the fact that the words and commas are to no purpose if in the day-to-day contacts with supervisors and workers there is no serious plan for bringing about better relationships. If owners are to obtain increased quantity and quality of output for the higher wage dollars they are now compelled to pay, they must institute a realistic personnel management program similar to the one described in this book.

Mr. Mooney has drawn largely on his extensive experience in chain-grocery operations to prove that the development of workers, supervisors, and executives pays dividends. Yet his devices for better selection and placement, for better training, for inducing job interest, enthusiasm, and effort are all equally applicable, and have proved themselves profitable to all human activity.

The author establishes six major factors which determine an employee's performance:

1 The character and ability of the employee
2 The nature of his work
3 The way he is introduced to his job
4 The opportunity he is given to do good work
5 The reward he receives for good performance
6 The supervision or leadership he receives.

Obviously these are equally important to employees at every level of responsibility. The book amply analyzes and explains each of them in respect to the development of workers, supervisors, and executives. The chapters on improving supervision can be particularly useful to managers who are seeking increased effectiveness throughout their organization, and who perhaps are worrying about the prospects of foremen's unions.

The thread which ties a whole labor-relations program together and which is the principal theme of the book, is training. Not the kind by which people learn as a result of "exposure" or of "osmosis," but rather the kind that is planned, organized, and followed through in a positive fashion. In the final analysis, management gets its result through the efforts of its personnel. Those results will be in direct ratio to the emphasis which management places on development—training—its employees so that they increase in their knowledge and skill and improve in their work habits and attitudes.

The author has well stressed the value and has well pointed out the methods for training. His practical philosophy is summarized in the following excerpt from the book.

"It is significant that doing the things necessary to achieve the employer's primary objective—better performance—will at the same time contribute to the realization of one of the worker's prime objectives—more recognition as an individual and more satisfaction from the work he does. Therefore an industrial relations program that incorporates means of realizing better performance and more satisfaction has the tremendous advantage of appealing to the self-interest of both employer and employee. This being the case, it is safe to say that when an employer provides the leadership to develop such a program and translates it into action, a response will be forthcoming from the worker because it will be to his advantage to make such a response."

Raw Materials From the Sea

Raw Materials From the Sea. By Edward Frankland Armstrong and L. Mackenzie Miall. Constructive Publications, Ltd., Leicester, England. Cloth, $6^1/_2 \times 8^1/_4$ in., 164 pp., 21 plates, 15s net.

Reviewed by L. A. Matheson[2]

THE ocean is a tremendous repository of raw materials, having within it a great share of the more-water-soluble elements. The authors have brought together in one place the stories of man's attempts and successes in winning chemicals from the sea. The result is a very readable account for the scientist, engineer, or the layman with some general chemical knowledge.

The first chapters review the general facts on the ocean with the theories concerning the relative abundance of the many elements as found, including the very rare such as gold and radium. A chapter on the biochemistry of the ocean details our present ideas on the mutual effects of the elements in the ocean and life in it. Fertilization with nitrates and phosphates may improve the food yield of the sea many fold as illustrated by Scottish experiments.

A chapter on solar evaporation of sea water recounts how this ancient industry still provides several million tons of salt per year. Ninety-nine per cent of the bromine is in the sea so that it is a natural source for our bromine for automotive antiknock. Processes which enable the separation of the very dilute bromine are described.

Magnesium metal and magnesia refractories are now obtained from the ocean in several locations. The development of these economical processes means that the world will never lack for magnesium raw materials. Seaweed is a source of many products.

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[1] Executive Director, Wallace Clark & Company, New York, N. J. Mem. A.S.M.E.

[2] The Dow Chemical Company, Midland, Michigan.

Potassium has been recovered directly from sea water in Norway by a precipitation process. The recovery of salts from the Dead Sea and many dried-up seas is discussed. The methods of obtaining potable water from the sea and of analyzing the many elements in it complete the book.

References to 1945 are included but it seems unfortunate that the authors did not include the monumental volume "The Oceans" 1087 pages, 1942 by Sverdrup, Johnson and Fleming which is a mine of information on scientific oceanography.

"Raw Materials from the Sea" is a very interesting volume and is heartily recommended to those with any interest in the chemicals in the sea. It is to be expected that the ocean will become much more important in our economy as we use up our more concentrated resources on land. Processes which are based on the sea have unlimited raw materials and are available to any nation with coastline.

Speed Regulators

Reviewed by R. W. Angus[3]

Contribution à l'Étude des Régulateurs de Vitesse. Considérations sur le problème de la stabilité. By Daniel Gaden. Editions La Concorde, Lausanne, Switzerland. Cloth, 6 × 9 in., 253 pp., 32 figs., 27f.

THIS book discusses the speed control and stability of operation of power-generating machines, more particularly those driven by water turbines, a subject of great importance since the building of the first central station, and more so as groups of generating stations began delivering power into the same distribution system. While a number of books on this subject have appeared from time to time, many of them, like the present one, are in a foreign language but with good translators available and with a work written in the clear language of M. Gaden, it is not a serious objection.

The author's name is known to readers of European hydraulic literature as he has written a number of articles, mostly on water hammer, and is the joint author, along with M. Calame, of a book on surge tanks. As Directeur des Ateliers des Charmilles, builders of some of the most notable turbines in the world, he has a knowledge of the practical requirements in the power house, and as a graduate of the University of Lausanne Engineering School he has the technical knowledge necessary to produce a well-balanced treatise. The work is free of reference to any specific governors, and does not even give an illustration of one, but shows them in diagrammatic form, giving the principles of construction along with a discussion of the general theory and fundamental considerations, so that the book has a broad application.

Beginning with a statement of general principles involved, it is explained that failure of satisfactory governing may be due to lack of speed control in the governor, or to instability or to lack of "promptitude" of action, and these are illustrated in case of the regular fly-ball head connected through a system of levers and the restoring mechanism to the servo-motor and thence to the turbine gates. Certain basic relationships are established, but in these the author has introduced "relative values," used throughout the book and really meaning ratios; thus the power P is not given in horsepower but in relation to a reference power P_0 and the ratio p of the one to the other is used. The same method is employed with speeds, torques, etc., and was apparently suggested by the author's reading of the work of Allievi on water hammer, where it will be remembered that one chart covers every practical case of pressure rise within its sphere and this much enhances its usefulness. Working on this line the WR^2 of the rotating masses is reduced to the "specific inertia" by dividing by the reference power, so that it is represented by a time in seconds. The advantages of this method are indicated in the charts shown throughout the book.

Proceeding step by step from the simple governor to the one taking advantage of inertia to hasten its adjustment, the author examines the influence of small oscillations in regulation, and the conditions under which these gradually die out, and in this connection he considers the relative effect of the governor's inertia element and shows how the curve of logarithmic decrement may be drawn in a given case. He makes an interesting use of vector diagrams and has an important chapter on the stability of groups working in parallel. The flywheel effect of the rotating masses and all other elements are considered.

One of the most important parts of the book is that dealing with the effect of water hammer pressure oscillations, and in this part a knowledge of Allievi's work is helpful but not essential. The conditions under which the oscillations tend to die out are examined and also those in which they tend to approach resonance with governor-produced oscillations, which is important in connection with long penstocks. After a full discussion of principles with numerical examples, the author has drawn a series of charts giving numerical results in very simple form by the employment of "relative values" for axes and by drawing curves of various parameters. These show the angular displacement of the water hammer and governor-produced waves, conditions for resonance and other factors, and have been prepared with great care so as to be very useful.

It is not possible to discuss all the features of this well-written book but a brief reference to the appendices may be made. The first of these deals with runaway speeds due to sudden rejection of full load and the effect of specific speed in this case, while the second one discusses tapering penstocks and the resonance effects due to changes in diameter causing partial reflections. The method of finding the equivalent uniform penstock is illustrated with a specific case where numerical values are used. The last appendix deals with "promptitude" of action of the governor and is accompanied with experimental results.

The book is a very creditable piece of work. The subject treated is complicated and yet mathematical difficulties have been almost entirely eliminated, and if the reader will spend time in studying the principles given he will find himself richly rewarded if he is working in the field covered. The freshness of the treatment and the convenience of the charts in practical problems further commend the book. To all interested in the design or operation of central stations this book should be valuable. The printing is clear and there are thirty-two charts and diagrams

Books Received in Library

Aircraft Annual 1946, edited by D. C. Cooke. Third annual edition. Robert M. McBride & Company, New York, N. Y., 1946. Cloth, $6^1/_2 \times 9^1/_2$ in., 304 pp., illus., diagrams, maps, tables, $3. A comprehensive survey is presented of recent developments in all phases of the aviation field. New types of airplanes, military, commercial, and private are described. Factual and statistical information is given concerning the airlines and the airplane-manufacturing industry of the United States. Records of the operations of the Army and Navy Air Forces during the latter part of the War are presented. New equipment and techniques are described, and a chapter is devoted to the National Airport Plan to meet the expected growth in civil aviation.

Analytical Geometry and Calculus. By H. B. Phillips. Addison-Wesley Press, Cambridge, Mass., 1942 (1946 printing). Cloth, 6 × 9¹/₄ in., 457 pp. and Index plus 21 pp., Answers to Problems, plus 47 pp., Supplementary Problems; diagrams, $5. The object of this text is to provide a course in analytical geometry and calculus for students of science and engineering. Certain fundamental topics in analysis needed for the logical development of calculus are discussed in the first chapter. An elementary treatment of vector analysis and functions of a complex variable are included for work in mechanics and for the analysis of various physical fields. The problems accompanying the several chapters are supplemented by a group of several hundred at the back of the book.

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[3] University of Toronto, Toronto, Canada. Honorary Member A.S.M.E.

A.S.T.M. Standards including Tentatives, 1945 Supplement. Part 1, Metals. 397 pp.; Part 2, Nonmetallic Materials, Constructional. 229 pp.; Part 3, Nonmetallic Materials—General. 503 pp. American Society for Testing Materials, Philadelphia, Pa., 1945–1946. Cloth, 6 × 9¹/₂ in., illus., diagrams, charts, tables, $4 per Part ($2.50 to A.S.T.M. Members). This supplement to the 1944 book of A.S.T.M. Standards brings it up to date by giving all the changes or additions accepted during the year 1945. Two hundred and fifteen standards are included, some sixty of which appear for the first time. The supplement appears, like the original work, in three volumes.

American Machinists' Handbook and Dictionary of Shop Terms. By F. H. Colvin and F. A. Stanley. Eighth edition, revised and enlarged. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1945. Cloth, 4 × 7 in., 1546 pp., diagrams, charts, tables, $5. This standard reference work for the machinist, toolmaker, and designer of machine parts provides a comprehensive collection of useful tables and data. The various phases of machine-shop work are covered thoroughly, including screw threads, gearing, measuring, and fitting. Additional chapters are devoted to metals and other materials, knots and slings, shop trigonometry, and railroad-shop data. There is a seventy-page illustrated dictionary of shop terms.

Annual Report on the Progress of Rubber Technology, vol. 8, 1944, edited by T. J. Drakeley. W. Heffer & Sons Ltd., Cambridge, England, for the Institution of the Rubber Industry, London, England. Paper, 7¹/₄ × 9¹/₄ in., 139 pp., tables, 12s, 6d. This review of advances in our knowledge of rubber and in its uses covers the work of the year 1944. Both natural and synthetic rubbers are discussed, their properties, production, testing, and compounding being described. Sections are devoted to tires, belting, hose and tubing, cables, and electrical insulation, footwear, mechanical rubber goods, sponge rubber, and other applications. Each section has an extensive bibliography. The volume is a first source of information for every user of rubber.

Atomic Artillery and the Atomic Bomb. By J. K. Robertson. D. Van Nostrand Co., New York, N. Y., 1945. Cloth, 5 × 7¹/₂ in., 173 pp., illus., diagrams, tables, $2.50. In simple language, without mathematics, this book treats of the equivalence and interconversion of mass and energy, the meaning of nuclear fission and nuclear chain reactions, and the major details of construction of the plants for producing atomic power and atomic explosives. The early work on the passage of electricity through gases leads into the discussion of electrons and the heavier, faster types of particles so important in our newer fields of science such as the release and control of atomic energy.

Le Bois, Matériau de la Construction Moderne. By J. Campredom, preface by M. Leloûp. Dunod, Paris, 1946. Paper, 5¹/₄ × 8¹/₄ in., 153 pp., diagrams, charts, tables, 240 fr. The author first deals with the structure and physical properties of wood. He then describes various methods of treatment of wood to increase its value as a structural material, such as impregnation, compression, and lamination. The last section covers the new uses for which wood has been made available, such as built-up beams, and sections formed by the application of heat and pressure.

Building an Engineering Career. By C. C. Williams. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1946. Cloth, 5¹/₂ × 8¹/₄ in., 309 pp, illus., diagrams, charts, tables, $2.50. An orientation course for freshman engineers. The author discusses what engineering is and how to study it, gives something of its historical background and calls attention to modern achievements. This edition has been revised.

Cavendish Laboratory. By A. Wood. University Press, Cambridge, England; The Macmillan Co., New York, N. Y., 1946. Cardboard, 4 × 6³/₄ in., 59 pp., illus., $1. In the seventy-two years since the Cavendish Laboratory was opened, it has become famous as a leader in physical developments. This little book briefly describes the development of the laboratory under Clerk Maxwell, Rayleigh, J. J. Thomson and Rutherford and calls attention to some epoch-making results.

Cours d'Analyse Infinitesimale, 2 volumes. By Ch.-J. de la Vallée Poussin. Vol. 1, eighth edition, 460 pp.; vol. 2, seventh edition, revised, 524 pp., 1946. Dover Publications, New York, N. Y. Cloth, 5¹/₂ × 8³/₄ in., diagrams, tables, $4 each (2 vols., $7.50). This standard French text provides both a working knowledge of advanced calculus for the technical student and the basis for a thorough understanding of the fundamental principles of analysis for the student of mathematics. Volume 1 deals with the differentiation of implicit and explicit functions of one or more variables, with the classic methods of integration, and with the fundamental formulas of the theories of curves and surfaces. Volume 2 continues the work on various types of integrals, takes up differential equations and the calculi of variations and of finite differences, and goes thoroughly into the subject of geometrical applications.

Descriptive Geometry. By E. F. Watts and J. T. Rule. Prentice-Hall, Inc., New York, N. Y., 1946. Cloth, 6 × 9¹/₄ in., 301 pp., illus., diagrams, charts, tables, $3. The theory of descriptive geometry is fully developed as a basis for the solving of engineering problems by graphical methods. Separate chapters are appended, dealing with precision in drawing, properties of plane figures, and stereoscopic drawing. Problems accompany each chapter to illustrate in a practical manner the material discussed.

Development of Improved Means for Evaluating Effects of Torsional Vibration on Internal Combustion Engine Installations. S.A.E. War Engineering Board of the Society of Automotive Engineers, New York, N. Y., 1946. Cloth, 8¹/₂ × 11¹/₄ in., 578 pp., illus., diagrams, charts, tables, $10 ($5 to members of S.A.E.). The twenty-six contributed papers collected in this volume describe instruments and techniques for measuring torsional vibration and for estimating nominal stresses, discuss the significance of estimated nominal stresses, and in one instance, indicate a simplification of instrumentation for indicating dangerous stresses. Both analytical treatments and actual test methods are considered. The general object of the project was to combine the present knowledge of the subject and provide a basis for further development.

Dictionary of Aeronautics with Glossaries of Aerological and Navigational Terms. By E. B. French. Mentzer, Bush & Co., Chicago, Ill., 1945. Cloth, 5¹/₂ × 8¹/₂ in., 129 pp., illus., diagrams, charts, tables $.75. Words and phrases in the field of aviation and aeronautical engineering are defined in a concise manner. The illustrations are designed to identify and relate a number of terms as a group. Separate glossaries are provided for aerological and navigational terms.

Dictionary of Metal Finishing Chemicals, including Tables of Specific Gravity. By N. Hall and G. B. Hogaboom, Jr. Metal Industry Publishing Co., New York, N. Y., 1945. Fabrikoid, 5¹/₂ × 8¹/₂ in., 129 pp., tables, $3. The chemicals used in metal finishing are listed with information as to grades, commercial packaging, chemical formulas, and synonyms.

Einleitung in die Mengenlehre. By A. Fraenkel. Third revised and enlarged edition, 1946. Cloth, 5¹/₂ × 8³/₄ in., 424 pp., diagrams, tables, $4. The first three chapters of this standard German work on the theory of aggregates cover the usual material: fundamentals and cardinal numbers; operations with cardinal numbers; order types and order numbers. The fourth chapter deals with attacks on the fundamentals and their consequences. The last chapter discusses the axiomatic structure of the theory of sets and the axiomatic method. There is a large bibliography.

Elements of Ammunition. By T. C. Ohart. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1946. Leather, 6 × 9¹/₄ in., 412 pp., illus., diagrams, charts, tables, $6. This book aims to present the novice in the design and development of ammunition with a clear account of the subject, covering all types. Starting with the conventional older types, the text covers the types developed between the two world wars and also those developed in the last few years. The text is based on the author's experience as a designer and lecturer at Picatinny Arsenal during the last six years, and treats the subject from the point of view of the designer, rather than the user.

Elementary Applied Aerodynamics. By P. E. Hemke. Prentice-Hall, New York, N. Y., 1946. Cloth, 6 × 9¹/₄ in., 231 pp., illus., diagrams, charts, tables, $3.25. The opening chapters discuss the physical properties of air and the flow of an ideal fluid. Following directly from these come the chapters on airfoil theory, including the compressibility effect. Propellers receive separate treatment, and the performance of a conventional airplane is discussed. A brief chapter on rotors and helicopters is included. The presentation has been kept as simple as possible, but some preliminary training in mathematics, physics, and mechanics is expected.

Gas Turbine Gas Charts (Research Memorandum Nos. 6–44). Research and Standards Branch, Bureau of Ships, Navy Department, Washington, D. C., 1945. Paper, 8¹/₄ × 10³/₄ in., 48 pp., diagrams, charts, tables.

This report was prepared to provide a means for rapidly and accurately calculating gas-turbine performance. Along with the charts is a brief description of their use and an appendix explains the method of calculation with actual examples of gas-turbine plant performance. A bibliography lists the original sources of the data from which the charts were prepared and the method of preservation was derived.

Grundzüge der Theoretischen Logik. By D. Hilbert and W. Ackermann. Second enlarged edition. Dover Publications, New York, N. Y., 1946. Cloth, $5^{1}/_{2} \times 8^{3}/_{4}$ in., 133 pp., tables, $2.50. An introduction to the subject of symbolic logic, this book demonstrates the application of strict formulas and methods for their manipulation to the field of philosophical logic. Four chapters deal respectively with: The propositional calculus; the calculus of classes; the simple function calculus, that is, the calculus of classes of individuals and of multiple relations between individuals; the logical paradoxes and the use of a theory of type to avoid paradox.

Industrial Research Service's Psychrometric Tables and Charts. By O. T. Zimmerman and I. Lavine. Industrial Research Service, Dover, N. H., 1945. Cloth, 162 pp., diagrams, charts, tables, $6.50. Complete psychrometric data are presented over the temperature range of —100 F to +1000 F. A partial list of the contents includes: volumes and enthalpies of air and water vapor; saturation humidities at various pressures; humidities along percentage-saturation curves and along adiabatic-saturation lines; properties of water and saturated steam; and vapor pressures of water, ice, and supercooled water. Explanatory text with illustrative problems precedes the main section of tables and charts.

Job Evaluation Methods. By C. W. Lytle. Ronald Press Co., New York, N. Y., 1946. Cloth, $6 \times 9^{1}/_{2}$ in., 329 pp., diagrams, charts, tables, $6. The author presents an analytic approach to the subject. The procedure of job analysis and evaluation is separated into functional steps as indicated by the chapter headings, in order to compare and select methods and characteristics to fit any given set of conditions. The application of evaluation to office and supervisory positions is considered and there is a special chapter on merit teting.

Macrae's Blue Book, America's Greatest Buying Guide and Hendricks' Commercial Register, Fifty-third annual edition. MacRae's Blue Book Co., Chicago, Ill., 1946. Cloth, 8×11 in., 3736 pp., illus., cloth, $15. This annual directory gives a complete listing of manufacturers in the United States, classified according to products. The first 400 pages of the volume contain an alphabetical list of manufacturers, producers, and wholesalers with capital ratings, location of branches, and in some cases, addresses of local distributors. The third and last section of the volume is an alphabetical list of trade names.

Manifesto for the Atomic Age. By V. Jordan. Rutgers University Press, New Brunswick, N. J., 1946. Cloth, $5 \times 7^{1}/_{2}$ in., 70 pp., $1.50. The impact of the release of atomic energy upon the industrial and social framework of human life is assessed in the light of the current uncertain state of affairs. The results of previous revolutionary changes in the world situation are demonstrated, and a forecast of the likely shifts in the technological, economic, biological, and political aspects of human existence is presented.

Manual for Water Plant Operators. By A. A. Hirsch. Chemical Publishing Co., Brooklyn, N. Y., 1945. Cloth, $5^{1}/_{4} \times 8^{3}/_{4}$ in., 386 pp., illus., diagrams, charts, tables, $6.50. Written for the practical man, this book gives a comprehensive picture of correct operating practice in clear and simple style. The several sections cover respectively: sources and procurement of water; basic methods of water treatment; special treatment methods; the distribution system; control tests; and a miscellaneous section covers emergencies, records, and data tables, with a brief bibliography.

Materials Handling Manual (II). Edited by M. M. Williamson and G. W. Williamson. Paul Elek, Ltd., London, E.C.1, England, 1945. Cloth, $5^{1}/_{2} \times 8^{3}/_{4}$ in., 488 pp., illus., diagrams, charts, tables, 30s. This volume deals with aspects of handling applicable to all industries. The material is divided into four main divisions: Continuous bulk movement, mainly horizontal, such as belt conveyers and aerial ropeways; continuous bulk movement, mainly vertical, as with elevators and pneumatic handling; continuous package handling, horizontal and vertical; intermittent movement, as earth moving, hoists, and trucks. The book is intended as a guide for engineers and designers for modernizing plants or preparing new layouts, and is profusely illustrated with photographs, sketches, and flowsheets.

Medicine in Industry. By B. J. Stern. Commonwealth Fund, New York, N. Y., 1946. Cloth, $5^{1}/_{4} \times 8^{1}/_{2}$ in., 209 pp., tables, $1.50. The author traces broadly the social, economic, legal, and professional setting within which industrial medicine has progressed, and discusses the development of knowledge which enables industrial physicians to cope with many diseases affected by occupations. Data are presented on the rates of industrial disability and the limited extent or preventive services. Recent developments in health and insurance programs are dealt with, the problems of the handicapped in industry are considered, and the relationships between industrial physician and general practitioner are discussed.

Metal Working and Heat-Treatment Manual, Vol. I. By F. Johnson, Paul Elek, Ltd., London, E.C.1., England. Cloth, $5^{1}/_{2} \times 8^{3}/_{4}$ in., 204 pp., illus., diagrams, charts, tables, 17s, 6d. This first volume of a series of four deals extensively with the characteristics and heat-treatment of carbon steels. It covers the influence of composition and treatment on structures and properties; describes practical operations such as forging, annealing, tempering, and machining; devotes two chapters to hardenability; and discusses mechanical properties and their testing. There is a supplementary chapter on the heat-treatment of tool steel. Successive volumes are planned as follows: Vol. 2, Alloy steels, cast-iron and nonferrous alloys; Vol. 3, surface-hardening; Vol. 4, furnaces and pyrometry.

Modern Plastics. By H. Barron. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1945. Cloth, $5^{1}/_{2} \times 8^{1}/_{2}$ in., 680 pp., illus., diagrams, charts, tables, $7.50. The introduction discusses raw materials and the polymerization process. The succeeding parts deal respectively with: Thermosetting resins and their plastics; cellulose plastics; vinyl plastics; other leading plastics, including casein; some important aspects of plastics, such as the use of high-frequency heating and physical testing methods. Processes and plastics are closely associated, as: Molding and phenolics; injection molding and cellulose acetate; extrusion and polyvinyl chloride; and fibers and nylon.

Modern Plastics Encyclopedia, 1946. Plastics Catalogue Corporation, New York, N. Y. Cloth, $8 \times 11^{1}/_{4}$ in., 1389 pp. + 10 charts, illus., diagrams, charts, tables, $6. ($7, Canada). This standard compendium of information on plastics covers a wide field, beginning with a review of recent progress. Methods of identifying and testing plastics are described, the varieties are discussed at length, and their qualities are considered from a practical viewpoint. Other sections deal with engineering design; methods of molding, extruding and casting; fabricating, finishing and assembling; machinery and equipment; laminates, plywood, and vulcanized fiber; coatings; synthetics and rubberlike plastics. There is a large amount of useful tabulated data including ten large folded charts in a special envelope.

Nature of Patentable Invention, its Attributes and Definition. By J. E. R. Hayes. Addison-Wesley Press, Cambridge, Mass., 1945. Cloth, $6 \times 9^{1}/_{4}$ in., 183 pp., $5. The author first discusses in considerable detail the concept of invention as a mental process. He then takes up the various phrases such as "new and useful result," "addition to the sum of knowledge," etc., by which the validity of an invention is tested and explains their interpretation. Other sections cover the analysis of ideas, tests for invention, and identification of results. The allowability and the proper expression of claims are dealt with. Throughout the book direct quotations from cases and judgments are extensively used to illustrate the points involved.

New Careers in Industry. By J. M. Amiss and E. Sherman. McGraw-Hill Book Co. Inc., Whittlesey House Division, New York, N. Y., and London, England, 1946. Cloth, $5^{1}/_{2} \times 8^{1}/_{4}$ in., 227 pp., illus., $2.50. The main types of jobs available in industry are discussed from several viewpoints. Necessarily, information is given about duties, working conditions, wages, and qualifications. Additionally, the authors emphasize the importance of the individual job, its place in the total pattern of industry, and opportunities for advancement. The field is covered from the machine operator to the salesman, from the supervisor of mechanical operations to the supervisor of personnel and labor relations. Suggestions are also given for planning for the necessary educational training and for the evaluation of one's own qualifications.

Nursing in Commerce and Industry. By B. J. McGrath. Commonwealth Fund, New York, N. Y., 1946. Cloth, $6 \times 9^{1}/_{4}$ in., 356 pp., illus., diagrams, $3. This authoritative guide to the duties and responsibilities of the industrial nurse covers a wide range of related topics as well. It discusses the physical facilities of the industrial health service, health programs, and nonoccupational illnesses and accidents. Rehabilitation, workmen's compensation, and industrial welfare activities are considered. Separate chapters are devoted to such important subjects as communicable disease control and sight conservation. Further references accompany each chapter.

Le Plan de Fabrication Aéronautique. By M.-P. Guibert, preface by J. Roos. Dunod, Paris, France, 1945. Paper, $6^{1}/_{2} \times 10$ in., 126 pp., diagrams, charts, tables, 255 fr. A general plan for assembly-line production of airplanes is established on a statistical and mathematical basis for the more efficient use of the facilities involved. The treatment is highly detailed and much of the material is presented graphically by diagrams.

Practical Sales Management. By H. Simmons. Prentice-Hall, Inc., New York, N. Y., 1946. Cloth, 6 × $9^{1}/_{4}$ in., 427 pp., illus., charts, tables, $5. Modern sales management fundamentals, including the requirements for, and the duties of, a sales manager, are discussed in Section 1. Section 2 deals with the selecting, training, and handling of salesmen. Visual selling aids, such as sales manuals and catalogs, are described in Section 3. The fourth section covers modern research in markets, products, consumers, and sales analysis. Section 5 includes a number of topics: sales meetings, selective selling, direct mail advertising, public speaking, etc.

Photography in Engineering. By C. H. S Tupholme. Faber and Faber Limited and the Hyperion Press Limited, London, England, 1945. Cloth, 7 × $9^{1}/_{2}$ in., 276 pp., illus., diagrams, charts, 42s. The ways in which the camera is being used to simplify the draftsman's work, to analyze raw materials, to make records of high-speed machinery, in studying the molecular structure of metals, etc., are presented in this volume, which summarizes conveniently much scattered literature. Bibliographies provide for further study.

Physical Constants of Hydrocarbons, Volume 3, Mononuclear Aromatic Hydrocarbons. (A.C.S. Monograph Series No. 78.) By G. Egloff. Reinhold Publishing Corporation, New York, N. Y., 1946. Cloth, 6 × $9^{1}/_{4}$ in., 661 pp., diagrams, charts, tables, $15. This present volume is a collation and evaluation of all melting point, boiling point, density, and refractive index data available before May, 1944. The classification mononuclear aromatic hydrocarbons excludes hydrocarbons having a fused ring structure, any ring of which is aromatic. A brief history of benzene, an explanation of the nomenclature, and a brief discussion of the properties and calculations precede the tables. Original sources are cited for all figures used.

Planning for Jobs. Edited by L. Fitch and H. Taylor. Blakiston Company, Philadelphia, Pa., and Toronto, Canada, 1946. Cloth, $5^{3}/_{4}$ × $8^{3}/_{4}$ in., 463 pp., tables, $3.75. The plans and suggestions presented in this book were selected from several thousand submitted essays and cover a wide range of opinions and points of view. The material is grouped under several headings: Measures to promote private investment, including tax reforms and the abolishing of restrictive practices; measures to promote consumption, including tax reforms and consumer subsidies; fiscal programs and monetary reforms, including public works and market programs; and measures dealing with the supply of labor and the labor market, including wage and labor-union reforms and work-sharing proposals. The object is to indicate the principal trends of public thinking.

Plastics Mold Engineering, the Fundamentals of Plastics Mold Design and Construction. By J. H. DuBois and W. I. Pribble. American Technical Society, Chicago, Ill., 1946. Cloth, $5^{1}/_{2}$ × $8^{1}/_{2}$ in., 494 pp., illus., diagrams, charts, tables, $7. The early chapters describe types of molds, tool-making equipment and methods, materials for mold making, and plastics product design. The succeeding chapters are devoted to detailed description of individual molds and specific molding processes. The book is profusely illustrated by sketches, photographs, and working drawings, and some forty pages of useful reference tables are provided.

Principles and Practice of Heat Treatment. By J. Winning. Second edition. Emmott & Co., Ltd., Manchester and London, England, 1945. Paper, $4^{3}/_{4}$ × $7^{1}/_{4}$ in., 108 pp., illus., diagrams, charts, tables, 3s, 6d. The first four chapters of this small volume deal with general principles, furnaces and equipment, case hardening, and hardening machines. The book devotes separate chapters to carbon and alloy steels, stainless and rustless steels, and nonferrous alloys. Material on the inspection of heat-treated parts is included, and there is a discussion of how to plan a heat-treating program for any particular job.

Relay Engineering. By C. A. Packard. Struthers-Dunn, Philadelphia, Pa., 1945. Fabricoid, $4^{1}/_{2}$ × 7 in., 640 pp., illus., diagrams, charts, tables, $3. Following an introductory and historical opening chapter are some fifty pages devoted to definitions of terms and illustrations with code designations of some 100 magnetic structures manufactured by the Company issuing the manual. Succeeding chapters deal with description of relays and auxiliary equipment, applications, and circuits, the selection of relays for specific tasks, installation and service work, and standards. A bibliography and an appendix of technical data are provided.

Report on Behavior of Ferritic Steels at Low Temperatures: Two parts. By H. W. Gillett and F. T. McGuire. War Metallurgy Committee of National Academy of Sciences, National Research Council; published by American Society for Testing Materials, Philadelphia, Pa., December, 1945. Paper, $8^{1}/_{2}$ × 11 in., illus., diagrams, charts, tables. Part 1, 55 pp.; part 2, 155 pp.; 2 parts, $4. This is the final report of an extensive War Research Project intended to secure a comprehensive set of experimental data on the low-temperature behavior of a number of commercial steels. Part 1 discusses in detail the tests applied, the experimental technique, the steels considered, and previous work done on the subject. Part 2 presents 155 pages of data tables, hardenability curves, and charts and diagrams showing test results.

Rubber in Engineering, prepared under the Direction of the Controller of Chemical Research of the Ministry of Supply and the Directors of Scientific Research of the Ministry of Aircraft Production and the Admiralty on the Basis of Research carried out by the Imperial Chemical Industries, Ltd. Chemical Publishing Co., Brooklyn, N. Y., 1946. Cloth $5^{1}/_{2}$ × $8^{3}/_{4}$ in., 267 pp., illus., diagrams, charts, tables, $5.50. Part 1, describing the rubber-like state, and Part 2, discussing the general properties of rubber, furnish engineers with a general survey of the information available on the theoretical aspects of the subject. Part 3 provides useful information on the compatibility and incompatibility of rubber properties in their relation to practical use, covers the bonding of rubber to metal, and discusses other aspects of rubber technology. Part 4 deals at some length with the principles of the design of rubber engineering components for shock absorption, vibration insulation, etc.

Science in a Changing World. By E. J. Cable, R. W. Getchell, W. H. Kadesch. Revised edition. Prentice-Hall, Inc., New York, N. Y., 1946. Cloth, 6 × $9^{1}/_{4}$ in., 622 pp., illus. diagrams, charts, maps, tables, $5. Intended for the general reader, this book presents the basic facts of the physical sciences in simple language. For each scientific principle the authors give an example from the range of everyday living. Beginning with weights and measures and the first simple machines, the book deals successively with physics, climatology, chemistry, geology, and astronomy, including the allied fields. The revised edition includes recent topics as atomic fission, radar, and electron microscope.

Sequential Analysis in Inspection and Experimentation, revised and enlarged edition, prepared by the Statistical Research Group, Columbia University, for the Applied Mathematics Panel, National Defense Research Committee, Office of Scientific Research and Development; published by Columbia University Press, New York, N. Y., 1945. Lithoprinted, loose leaf, fabrikoid binder, 10 × $11^{1}/_{2}$ in., paged in sections, diagrams, charts, tables, $6.25. Section 1 of this work discusses the general theory of the method as applied to inspection and experimentation. Sections 2 to 6 inclusive describe the practical operation of the system under varying conditions and for various purposes. Some of the properties and fundamental mathematical principles of sequential analysis are explained in the appendixes which occupy the last section.

Smoke Prevention Association of America, Conference on Smoke Abatement and Conservation of Fuels, Proceedings, Columbus, Ohio, Oct. 16–18, 1945. Smoke Prevention Association, Chicago, Ill. Paper, mimeographed, $8^{1}/_{4}$ × 11 in., 105 pp., illus., diagrams, charts, tables, $2. Fifteen papers are presented covering a variety of topics. The larger aspects of smoke abatement and fuel conservation are considered in the first group. Succeeding papers deal with such specialized fields as dust collection, the relation between meteorology and smoke abatement, the design of locomotive equipment, coal analysis, and incineration problems. An outline is submitted as a suggested approach to participation of the Weather Bureau in air pollution research.

Supervising People. By G. D. Halsey. Harper & Brothers, New York, N. Y., and London, England, 1946. Cloth, $5^{1}/_{4}$ × $8^{3}/_{4}$ in., 233 pp., tables, $3. For the use of those who are directly in charge of the working groups, the author presents a simple, straightforward statement of all the phases of supervision which can be improved by systematic study and application. The material, from job rating to morale improvement, has been taken from the practical experience of the author and others and gives specific suggestions for the solution of numerous difficulties.

Tables of Functions With Formulae and Curves (Funktionentafeln mit Formeln und Kurven). By E. Jahnke und F. Emde. Fourth edition. Dover Publications, New York, N. Y., 1945. Cloth, $5^{1}/_{2}$ × 9 in., 306 pp. + 76 pp., diagrams, charts, tables, $3.75. This collection of tables has again been reprinted, with many errors corrected and a supplementary bibliography. These changes increase the value of the book already great as the most comprehensive in its field.

Les Vibrations sur les Avions, Calculs, Essais, Remèdes. By M. Berthaume, preface by M. Vernisse. Dunod, Paris, France, 1946. Paper, $6^{1}/_{2}$ × 10 in., 79 pp., diagrams, tables, 275 fr. Beginning with a theoretical discussion of the characteristics of vibration in airplanes, this book proceeds to a practical treatment of the necessary calculations and methods of testing, with numerical examples. Information is given on methods for reducing these vibrations, with specific remedies for specified cases. The book is liberally supplied with illustrative diagrams.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

A.S.M.E. Aviation Division Holds Record Annual Meeting at the University of California, Los Angeles, Calif., June 3–6

THE 1946 A.S.M.E. Aviation Meeting at the University of California, Los Angeles, Calif., June 3, 4, 5, and 6, was attended by 1800 engineers. The meeting was sponsored by the Aviation Division, A.S.M.E., in co-operation with the Southern California Section, A.S.M.E., and the University of California at Los Angeles. Sessions were held in the evenings from 7 to 10:30.

The program consisted of 22 sessions as follows: general session, gas turbines, two applied mechanics, three instruments and regulators, three heat transfer, one fuel and lubricants, two hydraulics, two rubber and plastics, three production, two management, and two metals.

Much of the success of the meeting was due to the efforts of the general chairman, Timothy E. Colvin, chairman, Program Committee, L. M. K. Boelter, and Ray G. Roshong, chairman, Southern California Section.

The smooth operation of seven simultaneous sessions for three evenings can be credited to the Arrangements Committee under the chairmanship of Prof. W. E. Mason.

As usual, the University of California was the perfect host, co-operating in every way possible. The well-equipped classrooms were ideal for technical-session meeting places. The academic atmosphere of the proceedings was obvious at all sessions.

Summary of Sessions

The general session was held Monday evening in the Royce Hall Auditorium and was presided over by Dean L. M. K. Boelter. After a brief address of welcome, he introduced E. W. Rawlings, Brigadier General, chief of procurement division headquarters, Air Materiel Command, U.S.A., who spoke on "Air Industrial Planning in the Postwar Period."

General Rawlings pointed out that the four keys to air industrial planning are: (1) An adequate research and development program that carries through production in limited quantities to provide production proving and service testing. (2) The maintenance of a healthy nucleus of an aircraft industry capable of rapid expansion and supported by a program of continuing military production. (3) The assurance of air industrial reserve of production facilities and resources. (4) A program of specific industrial preparedness plans undertaken jointly between the Air Forces and industry to maintain our newest air weapons in a state of readiness for volume production.

General Rawlings then illustrated many features of his paper by a sound film released for the first public presentation and taken in actual combat in the air war over Germany.

J. Carlton Ward, Jr., president, Fairchild Engine Airplane Corporation, then spoke on the "Impact of Industrial Mobilization on Aircraft Industry." His paper was well co-ordinated with the preceding discussion. He said that "if the full significance of industrial mobilization does not reach the American public, we have no hope of real national security now or at any future time."

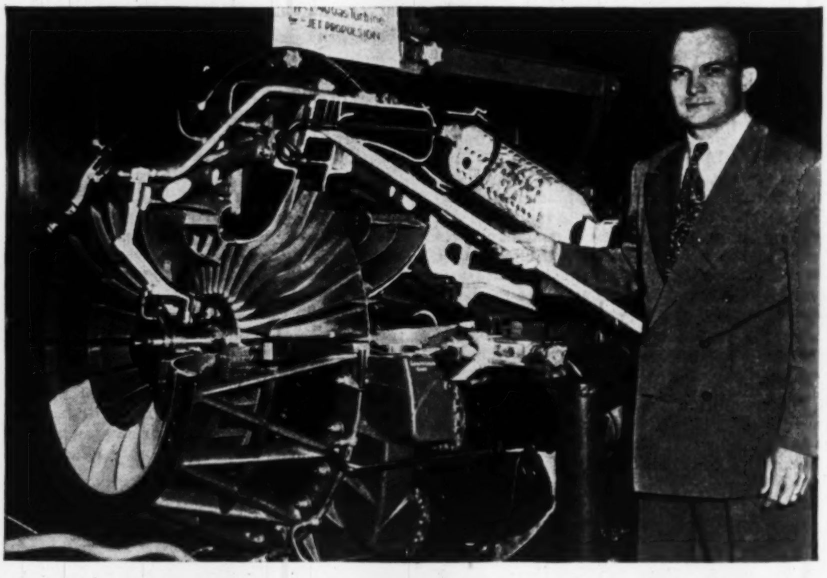
In conclusion, Mr. Ward offered certain recommendations for effective industrial mobilization as follows:

Industrial planning costs money, and the plans should be executed under military specifications and paid for only when competently performed. In order to avoid using funds for industrial planning and mobilization for other purposes, they should be earmarked in the budget and administered by an industrial-planning section of the armed forces.

Study of the accomplishments and the mistakes of the past and the incorporation of new ideas and techniques for the future should be carried on continuously, jointly by industry and military services. For this purpose the Industrial College of the Armed Services should be raised to the top rank of Army and Navy colleges, and industry should be asked to grant furloughs to competent key personnel, to be assigned there for courses of study as is now the case for Army and Navy personnel.

Too great an emphasis cannot be placed on the necessity for continued research and development. Government and industry should co-operate, each in its specialized field, without duplication or overlapping of functions.

Military planning, research and develop-



W. D. CRATER, GENERAL ELECTRIC COMPANY, EXPLAINS DESIGN OF GAS TURBINE AT THE 1946 AVIATION MEETING IN LOS ANGELES, CALIF.

ment planning, and production planning, as three functions, should have the same rank and be co-ordinated on the top level of national defense. Funds for each should be earmarked in departmental budgets.

An integrated aircraft industry, engaged in engineering the advanced designs and manufacturing in combat-test quantities, should be maintained as part of the peacetime military establishment.

Gas Turbines

A session on Aviation Gas Turbines, held on Tuesday evening, June 4, featured cutaway display models of the General Electric I-40 jet engine and its accessory assembly as used on the P-80 airplane. The session was attended by approximately 200 aviation engineers from the engineering departments of Southern California aviation concerns. M. J. Zucrow, executive engineer, Aerojet Engineering Corporation, Azusa, Calif., presided.

"Combustion and Ignition in Aircraft Gas Turbines" was the subject presented by W. D. Crater, engineer, General Electric Company, Los Angeles. Combustion-chamber flows, shapes, materials, temperatures, altitude starts, fuels, pressure drops, and other pertinent points were covered in the presentation and a lively discussion entered into by 20 individual discussers. The I-40 jet-engine cutaway model served to display the application of principles discussed.

"Characteristics of Jet Engines at High Flight Speeds" was the subject of the paper presented by C. A. Meyer, Westinghouse Electric Corporation, Lester, Pa. Shock waves on inlet and discharge nozzles and channels, effect of pressure ratios on efficiency, and temperature influence on thermal efficiency were explored in the presentation of the paper and its slides. A lively discussion ensued. (Reported by Bruce E. Delmar, recorder of the session.)

Production and Metals

Waldemar Naujoks, chief engineer, Steel Improvement and Forge Company, spoke on the "Development of Aircraft Forging."

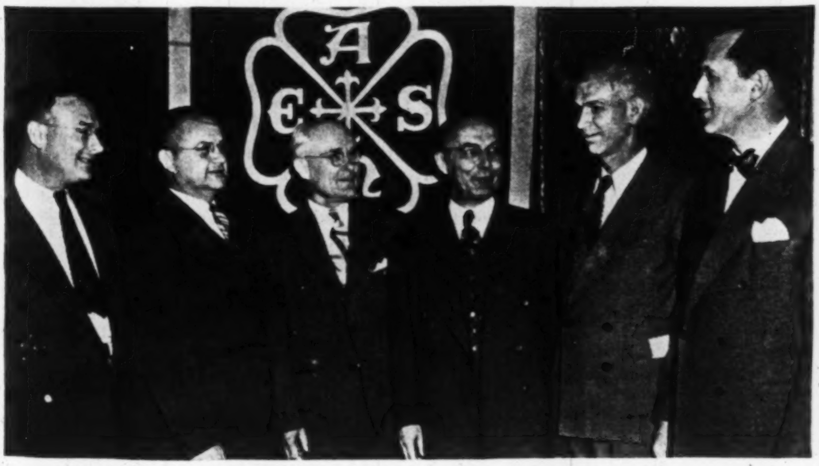
The paper outlined the essential reasons for the use of forgings in aircraft construction and indicated in brief the types of stresses in fuselage, landing gear, engine, and transmission assembly for which forgings are used.

Mr. Naujoks discussed the quality requirements covering aircraft steels, shapes, and sizes of parts, tolerance limitations, surface conditions, and other special considerations.

R. W. Steenrod, district heating specialist, General Electric Company, spoke on the "Fabrication of Steel Components by the Method of Copper Brazing." He said that there are several methods, established for many years, which have been employed to fabricate steel components of assemblies or parts. Each method offers certain advantages and occasionally certain disadvantages. Fabricating by the method of copper brazing often eliminates these disadvantages. Yet the success or failure of any one specific application is dependent upon how well the technique of copper brazing is understood during the design stage. Today's engineers are continually demanding from structural materials increased load and life with less material and weight and improved quality at less cost. (Reported by Wesley L. Orr, chairman of the session.)

Applied Mechanics I

D. O. Horning, engineer, Consolidated-Vultee Aircraft Corporation, spoke on "Aircraft Photoelastic Ventures." His paper dealt with the general uses of photoelasticity as an aid in aircraft stress analysis. Some of the misconceptions concerning photoelasticity were clarified. He gave a brief review of the fundamental principles involved in photoelastic procedures. Four typical problems of stress analysis solved by the photoelastic method were discussed: (1) Analysis of force in a bomb-bay lower longeron. (2) Stress analysis of a fitting based on photoelastic tests. (3) A photoelastic comparison of reinforcement at an opening in a tension member. (4) A photoelastic study of the effects of various cutouts on a variable section beam in bending.



AT THE A.S.M.E. AVIATION DIVISION MEETING IN LOS ANGELES, CALIF.

(*Left to Right:* J. C. Dillon, arrangements committee, Ray G. Roshong, chairman, reception committee, J. E. Younger, secretary, Aviation Division, A.S.M.E., J. Calvin Brown, vice-president A.S.M.E. Region VII, William Schroeder, program committee, T. E. Colvin, general chairman.)

Paul E. Sandorf, research engineer, Lockheed Aircraft Corporation, spoke on "Bending Rigidity and Column Strength of Thin Sections." The author made an excellent presentation of the highly technical subject. An interested discussion followed.

K. R. Jackman, chief test engineer, Consolidated-Vultee Aircraft Corporation, spoke on "Aircraft Acoustical Problems and Possible Solutions."

Test data on the basic "sound cabins" with several acoustical treatments were presented, and a comparison was made with the best empirical approach recently publicized by the Electro-Acoustical Laboratory at Harvard University. Some recent ground-noise analyses of jet aircraft and engines using augmented exhausts indicate the high-intensity components at relatively high frequencies that must be handled correctly, both in acoustical cabin treatment and in the protection of the hearing of test personnel.

The author described several surveys which were made in Convair's study of the noise levels inside and outside small planes and recommended acoustical treatment.

Instruments and Regulators I

T. H. Wianco, consulting engineer for instrumentation, spoke on "Instrumentation for Rocket Motors and Jet-Assisted Take-Offs." He said that in the development and testing of rocket motors it is necessary to measure and record a number of parameters such as time, temperature, pressure, force, and motion. In the earlier days of rocket development a camera was used to photograph at regular intervals an instrument panel on which was mounted hydraulic gages and other instruments. It was soon found that this method was unsatisfactory for recording transients and the rapid sequence of events which have to be known to enable making an accurate analysis of the phenomena. Accordingly, equipment was selected for the continuous recording of data.

The inking or stylus recorders have the advantage that the record can be inspected immediately after and even during the test, but they suffer from disadvantages of low-frequency response and high driving-power requirements.

Cathode-ray photography has the advantage of extremely high frequency response but it is not well adapted to recording more than one quantity at a time.

The galvanometer oscillograph has a moderately high frequency response, and will record a large number of variables simultaneously. Another important advantage is that many of the variables may be recorded on galvanometers directly without the use of amplifiers.

T. M. Blackmon, electrical research engineer, research laboratory, Douglas Aircraft Company, spoke on "High-Speed Multipoint Temperature Recorder." He said that an experimental instrument has been constructed to record ten or more temperature readings per second with an accuracy of one half per cent. The temperatures of a large number of points may be measured in sequence or successive readings of the same point may be made. The instrument combines high-speed photographic techniques with an expanded-scale null-indicating potentiometer system. The reference voltage is produced by a small, continuously rotating, commutator-type slide-wire. Electronic recognition of the balance ionizes a gaseous-discharge lamp which furnishes the illumination for photographing a slide-wire scale as a slider passes the balance point. A new channel may be selected after each revolution of the slide-wire. The method is, in essence, null-indicating rather than null-seeking. By Fourier analysis it is shown how to evaluate the frequency of operation of the inverter and the band of frequencies which the amplifier is required to pass, in terms of recording speed and maximum permissible error.

The basic method is also applicable to the measurement of strains, pressures, and the like in conjunction with appropriate bridge-type pickups.

Heat Transfer I

In his paper on "A New Method of Determining the Inside Air-Flow Distribution for the Thermal Anti-Icing of an Airfoil Surface," Julius M. Naiman, research analyst in air conditioning, Douglas Aircraft Company, developed design equations for determining the inside air-flow distribution for the thermal anti-icing of an airfoil surface. These equations incorporated all the essential variables of the double-skin air flow and of the D-shaped ducts applying heated air to the leading edge of the airfoil.

Solutions of these equations were developed by the author in a form for ready application to the determination of the air-flow distribution and of the temperature distribution through the double skin and along the D-shaped duct.

T. P. Jackson discussed "Aircraft Windshield Heating with an Artificial Boundary Layer" (co-author H. H. Hanger, Jr.). A prepared discussion was given by Ralph Hitchcock, Boeing Aircraft Company, on "Aircraft Windshield Heating with an Artificial Boundary Layer."

A. M. Mayo, air-conditioning design engineer, Douglas Aircraft Company, presented a paper on "Compartment Cooling—A Problem in Modern Aircraft." He pointed out that the requirements for compartment cooling are sharply increased by additional equipment and ever-higher speeds of modern aircraft. The type of cooling system most practical for a given airplane may in general be related to the speed of flight. Vapor-compression-cycle refrigeration appears promising for aircraft, without gas turbine or cabin pressurizing, at speeds below 450 mph. Air-cycle systems depending on compressed air from a gas turbine or cabin supercharger appear best up to approximately the speed of sound. A ram air cycle system seems best suited to the higher speeds within the atmosphere. Storage or radiation cooling and heating systems will be needed for human flight in space outside the atmosphere.

Fuel and Lubricants

DEAN L. M. K. BOELTER, CHAIRMAN, PROGRAM COMMITTEE OF THE 1946 AVIATION MEETING

In the paper "Additive-Type Lubricating Oils for Aircraft Engines," by W. E. Kuhn and J. E. Fields, The Texas Company, presented in the absence of the authors by W. A. McMillan, the problems of testing various oils from laboratory through full-scale operations were presented. The need of checking lubricating oil under all conditions was also pointed out.

In the presentation of the paper "Aviation Greases," L. W. McLennan, research superviser (co-author Earl Amott, research chemist), Union Oil Company, pointed out some of the troubles that confronted the grease industry during the war. Extreme operating conditions caused many headaches. He also discussed some new types of synthetic greases that will overcome many of the problems.

The paper also points out the need for good tests. As yet, the industry has not a complete series of tests to check greases for operating conditions. (Reported by C. Sandland, chairman.)

Hydraulics I

"The High-Speed Water Tunnel at the California Institute of Technology," by R. T. Knapp, associate professor of hydraulics, and director of the hydrodynamics laboratory, California Institute of Technology, and "Cavitation Characteristics and Infinite Aspect-Ratio Characteristics of the N.A.C.A. 4412 Hydrofoil Section," by James W. Daily, hydraulic engineer, hydrodynamics laboratory; instructor in mechanical engineering, California Institute of Technology, were presented at the Hydraulic Session.

These papers described a unique water tunnel and gave typical experimental results. With the aid of slides a complete description was given of the high-speed water tunnel, its performance, and its auxiliary equipment (14-in-diam throat, 70 fps maximum velocity, adjustable accurate speed of propeller pump, cooling, pressure control, three-moment balance, and force measurements.) Measured characteristics of an N.A.C.A. 4412 "hydrofoil" were compared with the characteristics of the corresponding airfoil. Details of the cavitation phenomena in the vicinity of the hydrofoil were explained with the aid of some excellent photographs. (Reported by R. G. Folsom, chairman.)

Rubbers and Plastics I

Frederic Selje, automotive consultant, in his paper, "Aircraft Materials and Techniques—Their Application to Automotive Design," discussed many of the factors affecting service and passenger comfort, particularly in buses, and mentioned the possible development of bus trains, comparable with truck-trailer combinations, cleanable plastic interiors, unison seats for passenger comfort, color psychology, and similar items.

F. W. Woerner, chief chemist, Reeves Rubber Company, presented the paper, "Mechanical Application of Latex-Dip Coatings." He pointed out that natural-rubber latex, latices of most of the so-called synthetic rubbers such as GR-S, Buna N, Neoprene, Thiokol, a few of the plastics, and synthetically manufactured latices are being used in the form of latices (water dispersions) for the deposition of films or casting of various articles. The properties of these films vary according to the base used and can be profoundly modified by the use of various modifying agents. These dipped coatings can be made soft and resilient, tough and abrasion-resistant, hard (like ebonite), oil-resistant, water-resistant, resistant to most chemicals, with special aging characteristics, flexible at low temperatures, microporous, and with special electrical properties. Latex coatings can be applied to fabric and cloth of all kinds, paper, wood, screens, wire, and metals. The various latices have demonstrated their usefulness as protective coatings for plating racks; lining pumps, tanks, and pipes; protecting fabric against abrasion or the deterioration by chemicals, chaffing strips, flexible ducts, cord, tubing, sheeting, flock base, sealants, and impregnants. (Reported by R. B. Stringfield, chairman.)

Production II

The panel discussion primarily dealt with the new processes for 75S aluminum alloy and only mentioned other alloys in comparison.

The panel was opened by Prof. Dan Finch of the University of California at Berkeley, who discussed the physical properties of high-strength aluminum alloy and reviewed the basic research program that was carried out at the University.

The four other panel speakers, who represented the local Southern California aircraft plants, spoke regarding the actual plant processes. These processes differed to some extent and made for most interesting discussion. Variations in processes indicated different concepts of desired ultimate quality, acceptance of outside advice and research data, and utilization of as much existing plant equipment and methods as possible.

The other speakers were: F. Robert Kostoch, process engineer, North American Aviation, Incorporated, "Heat-Treatment;" Mark P. Meinel, production-methods engineer, Lockheed Aircraft Corporation, "Forming and

Bending Limitations;" Tim P. Glenn, tool engineer, Douglas Aircraft Company, "Dimpling by Heat Conduction;" Thomas E. Piper, chief material and process engineer, Northrop Aircraft Corporation, "Dimpling by Resistance Heating." (Report by Walter H. Del Mar, chairman.)

Management I

In his paper, "Wage Incentives: Important Factors Frequently Overlooked," P. B. Crouse, consulting management engineer, said that his paper was based on the premise that wage incentives are essentially a psychological tool, therefore the value of any feature is determined by its psychological effect.

All too often so much attention has been centered on the objective of increasing production that the essential ingredient—effective psychology—is entirely overlooked.

The attitude of the employee toward incentives is analyzed to disclose undesirable features. Certain concepts are selected as representative of the general trend. It is emphasized that their vindication is beside the point. They effectively state the problem:

Concept 1: Wage incentives are used by management to get more work for less pay. If unopposed, management would use them to eventually get far more work per hour for no more pay per hour; Effect—distrust of management's purpose.

Concept 2: Management believes that labor should not earn more than about 20 per cent above day rates and that standards are so set as to require production increases of 50 to 100 per cent or more for this small increase in pay; Effect—apathy to the appeal of higher earnings.

Concept 3: If earnings exceed this preconceived level, management will restudy the job and set tighter standards, if necessary, changing methods to provide an excuse; Effect—deliberately restricted production.

Concept 4: Even if old rates are unchanged when new jobs are time-studied, the rates on new work are set relatively tighter (if high earnings have been made on the old rates); Effect—suspicion of all time study.

Concept 5: Whenever methods are improved management sets relatively tighter standards on the new work if good earnings have been made on the old; Effect—opposition to all methods improvement.

Concept 6: The whole relationship of management to labor is one of opposing interests and management will spare no effort to exploit labor in this conflict; Effect—deep-seated though often subconscious antagonism to every move of management.

When the psychological response to the incentive plan is as outlined, distrust, apathy, limited production, suspicion, opposition, antagonism result and there is little chance that the incentive plan can become an effective psychological tool.

These responses are traced back to their origin in the structure of the incentive plan.

The conclusion is advanced that management must be able to convince labor not only that such concepts are not warranted, but that quite the opposite is true. (Reported by V. L. Peickii, chairman.)

Metals II

The paper, "Fracture of Some Aluminum Alloys Under Combined Stress," by E. G. Thomsen, D. M. Cunningham, and J. E. Dorn, division of mechanical engineering, University of California, was presented by Professor Thomsen. There was considerable discussion after the formal presentation of this paper. Several members of the audience stayed after adjournment to discuss related problems and questions.

Heat Transfer II

G. T. Rowe, Douglas Aircraft Company, in his paper, "A Correlation of Measured and Predicted Flow Characteristics of an Aircraft Ram Air-Duct System," pointed out that frequently it is desirable, once an aircraft duct system has been designed and fabricated, to determine the flow characteristics of the system without undertaking a rather lengthy and costly series of flight tests. This paper outlines a method by which the altitude, air-speed, air-flow characteristics of an aircraft ram air-duct system may be predicted on the basis of a simple laboratory test and compares the predicted results with those measured by actual flight test. The method is useful in determining heating or cooling requirements for an airplane-cabin ram duct system.

H. H. Hauger's paper, "Thermal Anti-Icing of the Eagle Airfoil," was read in Mr. Hauger's absence by T. P. Jackson.

The paper presented the development and theory behind the anti-icing heat requirements for the Eagle airfoil. This airfoil is a small streamlined plastic housing for a radar antenna, employed on bomber-type aircraft and used for bombing through overcast during World War II. The theoretical calculations for the heat requirements are of singular interest at this time, inasmuch as use is made of advanced data, and the results of the most up-to-date investigations in the field of thermal ice prevention are applied. The curves presented allow a flexibility in the design of the attending duct work by not requiring one air flow at one air temperature. The air speed corresponding to the maximum heat requirements of the Eagle airfoil occurs at the approximate cruising speed of present-day airplanes.

Lewis A. Robert, Stewart-Warner Corporation, spoke on "Thermal Ice-Prevention System for Aircraft." The paper covered the broad subject of anti-icing requirements and specifications. An active discussion on the several controversial issues touched on in the paper took place. An extensive discussion of conductively coated windshields was started at Mr. Robert's request by Mr. Whittemore of the Pittsburgh Plate Glass Company.

Applied Mechanics II

The paper, "Shaking Aircraft Wings in Flight," presented by R. L. Reed of Consolidated Vultee Aircraft Corporation, dealt only with the instrumentation and test procedure for ground and flight vibration tests (vibration excited by mechanical oscillators). Data reduction and complete evaluation of all records were included.

He said that at the present time flight vibration tests are made only on airplanes where the flight characteristics are questionable, such as a flutter speed below the limit diving speed of the airplane. With the new high-speed airplanes, and especially in the case of those with unconventional designs, many more flight-vibration testing will be required so that unnecessary risks will not be required by the flight-test crews.

W. H. Gayman, speaking on "Rotational Drop-Testing of Airplane Main Landing Gears," described the novel support of the tail wheel, the dynamic factors involved during the drop, and the instrumentation for the measurement of travel and loads. Slow-motion pictures of the drop tests on the main landing gears of a PV-1 showed very clearly the deflections and motions of the gear during various drop tests. (Report by S. F. Duncan, chairman.)

Instruments and Regulators II

In their paper, "Helicopter Instrumentation," R. G. Hewell and C. F. Savage, General Electric Company, pointed out that instruments for helicopters are in two classes: Those which are similar to instruments used in the conventional-type airplane, and those designed especially to meet the needs of the helicopter's peculiar flying characteristics. The existing instruments are described. The conditions requiring special instruments are discussed and some theoretical approaches to solution are suggested.

In his paper, "Instrumentation for Jet-Propelled Airplanes," C. A. Edman, General Electric Company, compared the engine instruments required by aircraft powered by reciprocating engines with those necessary for aircraft using gas turbines, other instruments (flight, navigational, and auxiliary) having been found to remain unchanged. The conclusion is drawn that although fewer instruments are needed for jet airplanes, considerable development is

A.S.M.E. Calendar

of Coming Meetings

September 16–18, 1946
Industrial Instruments and Regulators Division Meeting With Instruments Society of America
Pittsburgh, Pa.

September 30–Oct. 3, 1946
A.S.M.E. Fall Meeting
Boston, Mass.

October 7–9, 1946
Meeting of Petroleum Committee of Process Industries Division
Tulsa, Okla.

October 24–26, 1946
Joint A.I.M.E. Coal and A.S.M.E. Fuels Division Meeting
Philadelphia, Pa.

December 2–6, 1946
A.S.M.E. Annual Meeting
New York, N. Y.

needed to provide satisfactory instrumentation. (Reported by A. B. Carder, chairman.)

Rubber and Plastics II

E. H. Snyder, research engineer, Lockheed Aircraft Corporation, spoke on the subject, "Laminated Edge Attachments for Acrylics." He stated that a new method of integrally bonding a strip of laminated material to the edges of acrylic canopies or windows has been developed.

A fast-acting light-sensitive catalyst has made it feasible to cure a laminate of relatively high strength to the edges of acrylic parts without the application of heat. Attachment can then be made through the laminated edge strip which distributes the loading to the clear acrylic material. This eliminates the possiblity of crack formation due to the concentration of bearing loads. The use of rubber grommets and metal liners is also eliminated.

Preliminary tests showed that this type of attachment was at least twice as strong as the conventional attachment. Accordingly, this attachment method was further developed and improved and applied to actual airplane parts such as canopies and cabin windows.

Jack Williamson, chief engineer, Glenn H. Taylor Co., presented a paper on "Sandwich Laminates with Medium-Density Cores." (Reported by John Delmonte, chairman of the session.)

Production III

N. A. Lombard, Douglas Aircraft Company, in his paper on "Reconversion Problems in Aircraft Tooling," discussed aircraft-tooling reconversion problems in general, with particular emphasis on those problems relating to economy and quality. A comparison of the aircraft tooling problems and those of other industries was made. The paper also covered the problems of ever-changing engineering design, availability of materials, rate of production, reconversion problems, and plant and machinery rearrangement.

In the paper, "Aircraft Moving Assembly Lines," T. S. Cristin, Douglas Aircraft Company, discussed the pros and cons of the various types of conveyer systems: Overhead, track, position or station method, and continuous-motion line. He concluded that an analysis of a job would have to be made, and perhaps several systems used. Light units of large volume are more adaptable for continuous-motion overhead lines. Large, heavy, small-production articles are more adaptable to "track position" methods. (Reported by Timothy E. Colvin, chairman of the session.)

Management II

P. C. Hamlin, National Supply Company, spoke on "Cost Control." He pointed out that costs have been high and thinking must be changed from speed of production to cost of production if reconversion is to be complete. The plan of attack in his organization is threefold: (1) The employees must be cost-conscious; (2) the system must be geared to enable installation of methods of improvement; and (3) adequate compensation should be given for a job well done.

In his paper, "Engineering Research-Laboratory Management," Maurice Nelles, Lockheed Aircraft Corporation, said that because of the tremendous increase in expenditures for research during the war and because of the entrance of the government into the domain of private research, it has been necessary, more than ever before to put research operations on a sound business basis. It has also become necessary to present research as a business venture in which the probability of obtaining useful results in a definite time must be assured.

Harry W. Case pointed out in his paper, "Management and Efficiency," that in order to offset loss of efficiency produced by wartime conditions and causes, a plan was evolved by one engineering-management group which consisted of: (1) Analyzing the basic contributing causes; (2) determining the specific correctible factors; (3) formulating a plan of action and (4) placing it into effect.

After being placed into effect and carried through to completion, the plan resulted in: (1) Reduction in over-all time required for engineering production; (2) improvement in specific methods; and (3) a more effective and complete utilization of the technical skill of the engineering personnel.

The success of the plan, in contrast to the failure of numerous other attempts using similar general approaches, was found to rest upon two interdependent contributing factors: (1) A sound and systematic industrial-engineering approach to the problem; and (2) utilization of psychological techniques to control the human variables involved which might have produced difficulties in the attainment of the engineering aims. Through systematic planning involving the control and timing of the psychological factors to agree with the industrial-engineering changes being carried out, the aims of the plan were accomplished successfully without any drop in the production curve. (Reported by V. L. Peickii, chairman of the session.)

Instruments and Regulators III

J. C. Cunningham, aviation engineer, Westinghouse Electric Corporation, pointed out in his paper, "Recent Developments in Aircraft Electrical Systems," that there have been several recent developments in aircraft electrical apparatus and systems which might influence the aircraft designer's choice of means of accomplishing accessory functions. These include improved direct-current generators and control of higher-capacity, high-temperature wire, improved fault protection, higher-voltage direct- and alternating-current systems, both constant- and variable-frequency.

In his paper, "Electrical Snap-Action Temperature Controls for Aircraft," J. R. Campbell, consulting engineer, The Paul Henry Company analyzed a thermostat known as the Cam-Stat with a view to making its characteristics more readily understood by those interested in aircraft temperature controls. (Reported by M. J. Zucrow, chairman of the session.)

Heat Transfer III

The symposium on heat anti-icing was attended by leading heat-transfer engineers from all parts of the country. The chairman of this session was R. C. Martinelli, University of California, Berkeley, Calif.

Metals III

In his paper on "Elevated Temperature Stretch-Flanging of Some Aluminum Alloys," E. G. Thomsen, University of California at Berkeley, Calif., presented some very interesting results of numerous stretch-flanging tests. Stewart Martin, Consolidated-Vultee Aircraft Corporation, in his paper on "High-Strength Light Alloys in Aircraft and Their Artificial Aging," discussed measurement of physical properties relative to quench methods, cold-work effect on aging, change of temperature for load during aging, use of oil quench, and many other essential topics. (Reported by William Schroeder, chairman of the session.)

Hydraulics

C. S. Sorensen, chief engineer, aviation manufacturing division, Gillfillan Brothers, Inc., presented by title, a paper on "High-Pressure High-Altitude Aircraft Hydraulic-System Pumps." A very interesting presentation of the "Use of Hydraulic Analogies for Studying Wave Phenomena in Gases" was made by R. T. Knapp and H. A. Einstein, both of the California Institute of Technology.

Plant Trip

A trip was arranged by E. Wayne Young to the Northrop Aircraft Corporation to inspect the Flying Wing XB-35, Bombardment Airplane. About fifty took advantage of this opportunity.

Information on Cementing and Assembly of Plastics Offered by S.P.I.

THE Society of the Plastics Industry, Incorporated, has announced that the fifth chapter of the S.P.I. Technical Handbook has been completed and that advance copies will be available for distribution about July 15, 1946.

This chapter is entitled "Cementing and Assembly of Plastics" and covers information on the mechanical assembly by rivets, bolts, screws, and inserts, as well as the cementing of thermoplastics and thermosetting plastics. A discussion of heat welding and the cementing of plastics to other nonplastic materials is also included.

Advance copies of this latest chapter may be obtained by writing to the Engineering and Technical Committee, The Society of the Plastics Industries, Incorporated, 295 Madison Avenue, New York 17, N. Y. There will be a nominal charge for the copies.

A.A.A.S. to Meet in Boston, Mass.

THE American Association for the Advancement of Science will hold its next annual meeting in Boston, Mass., Dec. 26 to 31, 1946.

President's Page

Engineering Objectives

How may we broaden the usefulness of our profession?

Recent discoveries in science have been greeted by many persons with confusion and fear.

Shall America answer this fear and insecurity of an atomic age by shaking its fist at the world or is there a more effective way?

I am convinced engineers believe there exists in the hearts of men a power that is greater than that of the atom—the power of *good will.* Good citizens everywhere must learn to release this power.

At this point may we remind ourselves of the timely advice of the British poet and chairmaker, William Morris:

> "If these hours be dark, at least do not let us sit deedless, like fools and fine gentlemen, thinking the common toil not good enough for us and beaten by the muddle; but rather let us work like good fellows trying by some dim candlelight to set our workshop ready against tomorrow's light."

In this spirit of increasing our usefulness your Council's Executive Committee recently invited the Meetings and Program Committee to meet with it and to discuss together what might be the general theme to guide the program-making for our national Society meetings.

After talking over all the possibilities commonly discussed—some too broad and vague and some too narrow in scope—we finally agreed upon the basic theme, "The Public Responsibilities of the Engineer." In the years just ahead I suggest we direct our attention to the nature of these responsibilities, having in mind particularly their civic and national, and perhaps their international, aspects. If this job of interpretation is well done, perhaps we may have a part in helping a world now struggling with the problems of readjustment.

D. Robert Yarnall, *President*, A.S.M.E.

Engineers Honor H. W. Craver, Director, Engineering Societies Library Since 1917

AT the Engineers' Club, New York, N. Y., on Wednesday evening, May 22, about thirty members of the Engineering Societies Library Board and of United Engineering Trustees, Inc., attended a dinner in honor of Harrison Warwick Craver, who recently retired as director of the Engineering Societies Library.

W. I. Slichter Recalls Early Days

Edwin F. Church, member A.S.M.E., professor of mechanical engineering, the Polytechnic Institute of Brooklyn and chairman of the Library Board, presided. Walter I. Slichter, fellow A.S.M.E., professor-emeritus of electrical engineering, Columbia University, who was appointed to the Library Board in 1913 and served as a member of it for 32 years, recalled some of the problems which faced the Board when Dr. Craver was engaged as director. The Library consisted of the three separate collections of the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. Later, when the American Society of Civil Engineers moved its headquarters to the Engineering Societies Building, its library, larger than the other society libraries combined, was added. No catalog of these four independent libraries was available, and Dr. Craver's first task was to combine the four libraries into a single collection and to prepare a catalog so that materials would be easily found for reference.

Professor Slichter said that members of the societies living outside New York were critical of the expense of operating the Library because they could not use it personally. To meet this criticism Dr. Craver persuaded the Library Board to institute the Service Bureau which provided searches, translations, and photostats, and later the loan of books. He also provided brief reviews of new books received by the Library for publication in the Society journals. These services to members living outside New York vastly expanded the usefulness of the Library and reduced the amount of criticism that had been leveled against it.

Certificate Presented to Dr. Craver

D. Robert Yarnall, president A.S.M.E., presented to Dr. Craver an illuminated certificate of appreciation signed by the presidents of the Four Founder Societies.

In his response Dr. Craver recalled that it was the desire of the engineering societies to provide a common library for their books which led them to seek funds for that purpose and interested Andrew Carnegie to contribute the money which not only assured space for the common library but facilities for offices and meeting rooms. This, he said, was a start toward the solidarity of the engineering societies. In 1905, he asserted, there was not more than one engineering library in the nation. In connection with the work he was then engaged upon he had occasion to consult the public library in Pittsburgh, Pa. He criticized that library because of the inadequacy of its technological materials. As a result of this criticism he was asked to organize a technical library service, which he did, only to find himself a librarian. The work he did at Pittsburgh, he said, was quickly imitated by the Cleveland Public Library and other progressive libraries. It was because of this library work at Pittsburgh that he had been asked to assume the directorship of the Engineering Societies Library, today the foremost engineering library in the nation.

N. S. Hibshman, member of the Library Board and dean, School of Engineering, Pratt Institute, proposed a toast to Dr. Craver which met with enthusiastic response.

Support of Library Urged

T. T. Read, member of the Library Board, professor of mining engineering, Columbia University School of Mines, said that one of the specific statements of purpose in the constitution of the American Institute of Mining and Metallurgical Engineers was "to maintain a library." In spite of this fact the library was rather neglected and he called for greater support of it by the directors of the societies.

C. E. Davies, secretary A.S.M.E., recalled that one of the objectives of the Institution of Civil Engineers, founded in 1819, was to make engineering literature available to young men. In his opinion, members of the engineering societies were "taking the library for granted." The situation called for thinking and planning "right now." The Library, he pointed out, must be more than an inert collection of books. It must be an institution of active service. He suggested that the acting director, Ralph H. Phelps, arrange to attend the coming conventions of the Founder Societies in order to acquaint himself with the desires and opinions of the societies' members living outside New York and to carry to such gatherings as the Group Delegates Conference of the A.S.M.E. assurance of the desire of the Library to be of service to all engineers, wherever located. He recalled that the engineers of Denver, desiring to set up an engineering library, had called upon Dr. Craver to advise them in the matter. On the basis of the work which Craver had started the Engineering Societies Library might see to it that many centers of contact were established in cities where large numbers of engineers reside. If these centers of contact were supplied with microfilm copies of the catalog of the Engineering Societies Library, a rapid and valuable service would be available to engineers. It was in the direction of expanding services, he concluded, that the Library Board should move.

New Acting Director Speaks

Ralph H. Phelps, acting director of the Engineering Societies Library, said that the engineers had a wonderful library but it needed a great deal of publicity and pushing. He would be glad to attend the conventions of the Founder Societies and help "sell the library." Expanded services cost money, he warned, and pointed out that the current Library income was only $1000 in excess of the income of the peak year, 1931. Library income, he said, amounted to 60 cents per member, yet the American Library Association was authority for the statement that reasonable service costs a minimum of one dollar per person. If every engineer would support the Library through his own society, the Library "would go places." It was, he concluded, the foremost engineering library and it was the task of the Library Board to keep it so.

Research Begins in a Library

A. R. Mumford, fellow A.S.M.E., and former chairman of the Library Board, expressed his personal thanks to Dr. Craver. It had been his good fortune, he said, to serve on the Library Board and he had learned much about libraries from Dr. Craver. He had felt that it was not right for him to accept reappointment on the Library Board when his term expired as in doing so he would deprive some other engineer of learning about libraries. He had always marveled at Dr. Craver's ability to answer questions. It had been his experience that representatives of the societies' sections were always questioning the reason for supporting the Library. All engineers have a common interest in research, and as Dr. Craver had taught him, all research should begin in a library. He pointed out that many searches and bibliographies made by the Library to meet some engineers' need, were available for the use of others and this fact should be widely publicized. Even if these searches were several years old, the increment cost to bring them up to date was negligible compared with the cost of duplicating the entire effort or the loss of time and money involved in commencing a research project without first making a library search. Many engineering papers reported conclusions that could have been found in a library if a proper search had been made of the existing literature. He reported that an Australian librarian had made the trip to New York in wartime for the specific purpose of visiting two libraries. One of these was a city public library in New Jersey; the other was the Engineering Societies Library.

Extended Services Suggested

James W. Laist, member and former chairman of the Library Board and treasurer and production manager, Electrons, Inc., Newark, N. J., emphasized the value of the service features of the Engineering Societies Library. In his opinion the Library was not used by engineers as much as the value of such use warranted. This was an educational problem, he said, and it was one of the functions of the societies to teach engineers how to discover facts useful to them.

Ralph Roosevelt, a representative of the A.I.M.E. on the United Engineering Trustees, Inc., suggested that the Library should be better advertised and proposed a monthly service of reviews to which engineers might subscribe. He noted that during the War a group of Army engineers had taken quarters in the the building adjoining the Engineering Societies Library and had "worn out the books without paying a cent."

R. H. Barclay, member of the Library Board, chief electrical engineer, J. G. White Engineering Corporation, New York, N. Y., said that the Board was considering methods of publicizing the library and that the Board would purchase modern photostat equipment as soon as any was available on the market.

Sydney H. Ball, former member of the Library Board, partner, Rogers, Mayer, and Ball, New York, N. Y., said that he had been a close friend of Dr. Craver for twenty-five years. In that time he had never had a problem that Dr. Craver could not solve. The dinner was given to Dr. Craver not because he was a good librarian but because "everyone loves him."

A.S.M.E. I.I.& R. Division to Hold First National Meeting

THE Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers will hold a national meeting at the William Penn Hotel, Pittsburgh, Pa., Sept. 16 and 17, 1946. According to tentative plans, this meeting, the first national meeting in the history of the Division, should deserve the attendance of all engineers interested in instrumentation.

The meeting will be held in conjunction with the "Instrumentation for Tomorrow" conference and exhibition, sponsored by the Instrument Society of America. The first two days of the I.S.A. Conference, however, will be devoted exclusively to meetings of the A.S.M.E. Industrial Instruments and Regulators Division. In planning the program an effort is being made to avoid simultaneous meetings.

The high light of the A.S.M.E. technical program will be a symposium on "Controllability of Combustion Processes." This event, to be held Monday afternoon, Sept. 16, is expected to stimulate much discussion and interchange of valuable information. Several papers will be presented.

On Tuesday, Sept. 17, there will be one morning session and one afternoon session, each of which will be devoted to a particular phase of instrumentation.

The social program will include an A.S.M.E. Industrial Instruments and Regulators Division dinner on Monday evening and luncheons on Monday and Tuesday.

Plans call for meetings of the various committees of the Division, each scheduled so that members will be able to attend all technical sessions.

Because of the current hotel situation it is urgently recommended that members planning to attend the meeting make reservations immediately with the hotel of their choice. In addition to the William Penn Hotel, arrangements have been made for A.S.M.E. accommodations at the Roosevelt Hotel, Fort Pitt Hotel, Henry Hotel, and the Pittsburgher Hotel, all of which are within walking distance from headquarters at the William Penn Hotel. In writing for reservations, mention should be made of the A.S.M.E.-I.S.A. Meeting.

A.S.M.E. 1946 Fall Meeting to Be Held in Boston, Mass., Sept. 30 to Oct. 3, 1946

THE 1946 Fall Meeting of The American Society of Mechanical Engineers will be held at the Statler Hotel, Boston, Mass., Sept. 30 to Oct. 3, 1946. Although the meeting was originally planned as a three-day event, so many of the Professional Divisions had papers to present, that it was necessary to extend the program one day in order to provide an adequate number of sessions.

Technical Sessions

Eighteen technical sessions have been planned. These include: Aviation, Heat Transfer, Hydraulics, Management, Metals Engineering, Wood Industries, Production Engineering, Textile, Power, Applied Mechanics, Machine Design, and Training and Education.

The social part of the meeting will consist of three dinners and three luncheons at which prominent men in the fields of engineering, business, and education will speak on general topics of national interest.

Inspection Trips

The program of inspection trips will be of special interest to many members. Visits are being planned to the Massachusetts Institute of Technology, the General Electric Company, and many other places of industrial, educational, and historical interest.

Harold M. King, head of the turbine department, General Electric Company, West Lynn, Mass., is the general chairman of the Boston Section Committee working on the plans for the A.S.M.E. 1946 Fall Meeting.

Coal-Mining Industry Sets All-Time Safety Record

THE American coal-mining industry achieved a new high in underground safety during 1945. The tentative fatality rate per million tons of coal produced reached a new all-time low of 1.72. In human lives this means that more than 3500 are alive today, who might have been killed had the fatality rate of the industry remained at its 1916–1918 value of 3.91.

This record performance in mine safety is attributed by Daniel Harrington, chief, health and safety division, Bureau of Mines, to the improvements in mine conditions stimulated by the Federal Coal Mine Inspection Act of May 7, 1941.

All mines employing more than 25 men are inspected annually and recommendations are made for improving any situation or condition which could affect the physical welfare of the miners. During the last year this work was carried on by a group of 107 inspectors and 10 engineers, who made more than 3000 reports.

By increasing the inspection force to 250 inspectors and engineers, Mr. Harrison feels that the record fatality rate for 1945 can be further reduced by 50 to 60 per cent.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, May 23, 1946

A MEETING of the Executive Committee of the Council was held in the rooms of the Society, May 23, 1946. There were present: D. Robert Yarnall, chairman; R. F. Gagg, J. N. Landis, A. R. Stevenson, Jr.; A. R. Mumford (Sections); K. W. Jappe, treasurer; C. E. Davies, secretary; and Ernest Hartford, executive assistant secretary.

The following members of the Committee on Meetings and Program attended the meeting in response to an invitation from the Executive Committee: R. A. North, E. S. Rowell, and G. B. Warren.

Dues of Canadian Members

Upon recommendation of the Finance Committee, it was voted to accept payment of dues from members residing in Canada in Canadian currency until Dec. 1, 1946, but to require that payments from such members after that date be made either in American money or the equivalent.

Nuclear Energy Safety Code

In the light of an opinion expressed by the Committee on Nuclear Energy Applications that the time has come for preparation of standards, test codes, and safety codes in the application of nuclear energy, and upon recommendation of the Board on Codes and Standards it was voted to establish tentative standards, test codes, and safety codes covering construction and operation of nuclear-energy power plants.

Power Test Code

Upon recommendation of the Power Test Codes Committee it was voted to adopt as a standard practice of the Society the 1946 revision of the Test Code for Stationary Steam-Generating Units.

Honors and Awards

Upon recommendation of the Board of Honors and Awards, it was voted to approve the presentation of the A.S.M.E. Award for 1946 to Morris E. Leeds, chairman of board, Leeds and Northrup Company, Philadelphia, Pa., "for his outstanding achievements in the invention and development of electrical and temperature-measuring instruments, and in the field of industrial relations." Presentation will be made at the Annual Meeting.

Following consideration of the topic, "The

Engineering Method—Is It Applicable to Most of the Professions?" in connection with the 1947 Charles T. Main Award, it was decided that while the idea should provide an interesting subject for a paper, clarification of the wording of the suggested topic should be attempted.

International Relations

Upon recommendation of the Joint Committee on International Relations and in the interest of simplification and economy of effort, it was voted to discharge with sincere thanks, the A.S.M.E. Committee on International Relations and to refer in the future all questions affecting A.S.M.E. policy on international relations to the members of the A.S.M.E. participating in the Joint Committee on International Relations.

Salary Administration

Upon recommendation of the Committee on Organization, the secretary was authorized to establish and administer, subject to normal review and approval by committees having jurisdiction, a formalized plan for job evaluation and salary administration for employees of the Society.

Appointments

The following appointments were approved for the record:

Power Test Codes Committees: No. 13 on Refrigerating Systems, Everett P. Palmatier; No. 22 on Gas Turbines, W. A. Wilson.

Special Research Committee on High-Speed Milling with Carbide-Tipped Tools, H. T. Johnson, R. F. Onsrud, and Ernest Reaney.

Biography Advisory Committee, George F. Bateman, J. M. Juran, and Ronald B. Smith.

Nuclear Energy Application, Admiral H. G. Bowen.

Washington Award Commission, Ralph E. Turner.

Conference of the Office of Domestic Commerce, Washington, D. C., R. L. Goetzenberger.

Coming Meetings

A report of the Committee on Meetings and Program covering its plans for general sessions at coming meetings was heard. The report was discussed and the Committee was encouraged to proceed along the general lines recommended in its report.

Proceedings of Time-Study and Methods Conference Now Available

THE Conference Proceedings of the Time-Study and Methods Conference, held in Hotel Pennsylvania, New York, N. Y., April 26 and 27, 1946, by the Society for the Advancement of Management and the Management Division of The American Society of Mechanical Engineers, have been published in the July, 1946, issue of *Modern Management*.

A copy of the Proceedings will be sent to all who attended the conference. Additional copies are available at $1.50 per copy at The Society for the Advancement of Management, 84 William Street, New York 7, N. Y.

L. K. SILLCOX

L. K. Sillcox Receives Medal From British Engineers

DR. L. K. SILLCOX, fellow A.S.M.E. and A.S.M.E. Medalist, 1943, vice-president, New York Air Brake Company, was presented the Gold Medal of the Institute of Locomotive Engineers of Great Britain at a testimonial dinner held in his honor at the Union League Club, New York, N. Y., June 5, 1946.

The presentation was made by W. S. Graff-Baker, chief engineer, London Passenger Transport Board, and retiring president, The Institute of Locomotive Engineers of Great Britain, before more than fifty high-ranking engineers and executives of the American railroad industry.

Dr. Sillcox was presented with the Gold Medal Award in recognition of the excellence of his paper "Power to Pull" which covered a method for appraising the relative performance of steam and Diesel locomotives. The paper was presented at one of the 1942–1943 sessions of the British Institute and was judged the best technical paper presented during that year.

War conditions delayed the presentation of the award.

W. M. Sheehan, vice-president, General Steel Castings Corporation, acting for K. F. Nystrom, chairman, Railroad Division of the A.S.M.E., was toastmaster. D. Robert Yarnall, president A.S.M.E., introduced Mr. Graff-Baker, who made the presentation of the Gold Medal Award to Dr. Sillcox. Mr. Graff-Baker in a brief address, described some of the experiences of the London Passenger Transport Board during the difficult days of the blitz in London.

Others at the speakers' table were: D. W. Fraser, chairman, American Locomotive Company; H. N. Davis, past-president A.S.M.E., president, Stevens Institute of Technology; F. A. Schaff, president, The Superheater Company; C. P. Gross, chairman, New York City Board of Transportation; R. B. McColl, president, American Locomotive Company, and C. P. Whitehead, president, General Steel Castings Corporation.

Local Authorities Consider Safety Suggestion by Plainfield Section

MUNICIPAL police forces in New Jersey are considering the merits of a suggestion made by the Plainfield Section of the A.S.M.E. in their safety resolution of February, 1946, addressed to the New Jersey Commissioner of Motor Vehicles. The resolution recommended that a change be made in the current practice of handling buses at urban street intersections.

Concerned over the dangerous situation created every time a heavily loaded bus discharges passengers at a busy intersection, the Plainfield Section resolution suggested that buses be required to stop on the far side of an intersection beyond the stream of cross-avenue traffic. Unobserving passengers descending from the bus and bent on crossing the avenue, would be required, under the new method, to walk to the rear of the bus. The change would, eliminate the dangerous congestion of descending bus passengers and cross-avenue traffic which has been responsible for many accidents.

The resolution also suggested that each private automobile be required to carry a small card, conspicuously posted, showing the basic traffic laws of the state. Paper shortage, according to the Commissioner of Motor Vehicles, precluded the adoption of the second suggestion.

William L. Batt Speaker at Georgia Commencement

WILLIAM L. BATT, past-president and honorary member, A.S.M.E., president, SKF Industries, Inc., was speaker at the commencement exercises of the Georgia School of Technology on June 2[illegible], 1946.

W. S. GRAFF-BAKER, RETIRING PRESIDENT, THE INSTITUTION OF LOCOMOTIVE ENGINEERS OF GREAT BRITAIN (*left*) TALKS TO ERNEST HARTFORD, EXECUTIVE ASSISTANT SECRETARY, A.S.M.E.

Engineering Societies Library Issues Information Folder

A FOLDER, "How to Get Engineering Information" has been issued by the Engineering Societies Library, 29 West 39th St., New York 18, N. Y., for the benefit of persons using the library. It describes the services of the library that are available to anyone. It also lists the special rates available to members of the Founder Societies and tells how books may be borrowed by numbers.

Services for All

The scope of the services offered by the Engineering Societies Library is such that its large store of information is available to those who cannot visit the Library as well as to those who can; to those who are members of the Founder Societies and to those who are not members. The Library services include the following:

Reading Room

Anyone may visit the free Reading Room and use all the resources of the Library. A trained staff is ready to help the reader and to direct him to the best sources so that he will not waste his time in aimless searching. The Reading Room opens at 10 a.m. weekdays. Mondays to Fridays it closes at 10 p.m. and Saturdays at 6 p.m., except during the summer when it closes at 5 p.m. every day. It is closed on Sundays and most legal holidays.

Service Bureau

Distance and lack of time prevent many from coming to the Library. To serve these persons, a specially trained staff is available to make literature searches, translations, and copies of library material. All services are rendered at cost.

Searches. The Service Bureau handles questions on any engineering subject that can be answered by consulting the existing technical literature. This service ranges from recommending books on a specific subject to the preparation of comprehensive annotated bibliographies. The original publication, if available in the Library, is examined and is listed only if it is pertinent to the search. Literature searches are made for all purposes including that of disclosures related to patents.

Searches are undertaken to suit the exact specification of the inquirer. To do this the Library needs to know:

1 The subject, stated as exactly as possible with indication of those phases to be included and those, if any, to be excluded. Should the subject be covered very thoroughly or will a less complete search suffice?

2 Period of time to be covered.

3 Is the search to cover materials in all languages or only in English? Is it to be restricted to material from any country or countries?

The charge for searching is $2.50 per hour. On request, the cost of covering a given field for a given period will be estimated if the nature of the search makes this possible. A charge is made only for the time used.

Translations. The rates charged per hundred words for English translations of technical articles of ordinary difficulty are:

German, French, Dutch, Italian, Spanish	$1.00
Russian, Polish, Portuguese, Danish, Swedish, etc	1.20
Japanese	3.00

A small additional charge will be made for the extra time required for articles that contain a high proportion of formulas or other difficult material. The cost of any translation will be estimated if requested, but time can be saved by indicating in your first letter the amount you are willing to pay. If this is sufficient to cover the cost, the work of translating can begin at once. The cost will be the same whether or not an estimate is supplied, as the work is done at cost.

Photostats and Microfilm. Photostatic copies of material in the Library can be supplied for 30 cents a print. This price is for 11 × 14 inch, white on black (negative) prints. Any two facing pages which together measure not over 11 × 14 inches can be taken on one print. Larger material will require one print per page. Black on white (positive) prints cost an additional 30 cents each. Reduction or enlargements can be supplied.

Microfilm is economical for copying long articles; photostating is generally preferable for short ones. As most technical articles are short, the Library does not have equipment for microfilm copying, but by arrangement with another organization, the Library can supply microfilm copies of its material. Any one article from a magazine can be supplied for $1.50 regardless of the length of the article.

Payment for Services. As all services are rendered at cost, payment in advance is requested when the exact cost of the work is known. Invoices will be sent when payment in advance is impracticable.

Special Rates and Services for Members of the Founder Societies

The Engineering Societies Library is supported largely through the allotment of a portion of the dues of the members of the Founder Societies (American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and American Institute of Electrical Engineers). For this reason individual members of these societies receive special rates on services and they may borrow library books. Minor requests from members are handled without charge. All other services of the Library are also available to members.

Rates. Members of the Founder Societies who order work for their personal use and pay by personal check will receive:

1 A discount of 20 per cent on searches.

2 A discount of 20 per cent on translations.

3 A reduction of 5 cents on each photostat print.

Loans of Books. Because the Library's material is valuable and much of it in frequent demand, the Library Board has established the following rules governing the loan of books:

1 Books, including bound serial publications, may be borrowed by any member of a Founder Society, if in good standing and residing in the continental United States or Canada. (Applicants are asked to name their society.)

2 A charge of 25 cents a week or fraction of a week will be made for each volume borrowed.

3 The maximum length of time for any loan is two weeks, not counting time in transit.

4 Members may have as many as three volumes on loan at one time.

5 Return postage and insurance must be paid by the borrower.

6 Rare books and reference books are lent only after approval by the Library Board.

Requests should be addressed to the Engineering Societies Library, 29 W. 39th St., New York 18, N. Y.

Lincoln Arc-Welding Foundation Offers $200,000 in Awards

THE James F. Lincoln Arc-Welding Foundation, Cleveland, Ohio, has announced a new project known as "The $200,000 Design-for-Progress Award Program," for those engaged in the design, manufacture, or construction of any type of machinery or parts.

Awards are to be offered in 15 major classifications. Of these, three classifications of the program are devoted to machinery: Functional machinery, industrial machinery, and personal-service machinery. Collectively, these three classifications embrace 18 divisions of machinery.

Eighty-four awards totaling $46,200 have been established for the machinery-design and manufacturing field alone.

Complete details of "The $200,000 Design-for-Progress Award Program," which will close June 1, 1947, may be obtained by writing the Secretary, The James F. Lincoln Arc-Welding Foundation, Cleveland, Ohio.

T. K. Sherwood New Dean of Engineering at M.I.T.

THE appointment of Thomas K. Sherwood as dean of the School of Engineering at the Massachusetts Institute of Technology has been announced by Karl T. Compton, president of the Institution. Professor Sherwood has been deputy dean of engineering since last February as well as professor of chemical engineering.

During the war Professor Sherwood carried through a variety of important assignments for the Office of Scientific Research and Development, which demonstrated his successful coupling of practical engineering with a fundamental scientific point of view.

A.S.M.E. Textile Division Forms Heat Processing Committee

THE initial meeting of the newly formed Heat Processing Committee of the Textile Division of the A.S.M.E., which combines and replaces the former Heat Processing and Curing Equipment Committee and the Drying Committee, was held at the Engineers Club, Boston, Mass., on Monday evening, April 1, 1946.

The meeting was opened by C. D. Brown, chairman of the Textile Division, who outlined briefly the purpose of this Committee, pointing out that it was the aim of the Activities Committees to obtain accurate and useful data for the use of the several thousand mills served by this and other organizations.

Mr. Brown introduced F. D. Snyder, the new chairman of this Committee.

W. O. Jelleme, former chairman of the Heat Processing and Curing Equipment Committee, read a report covering studies made by this Committee. He also submitted an outline covering a code for Heat Processing and Curing.

Mr. Snyder, chairman of the Heat Processing Committee, gave an interesting paper on two new methods of drying and processing textiles, namely, Infrared and Dielectric Heating. Each method was clearly and concisely described.

The audience, representing equipment manufacturers, machine manufacturers, and mill executives, all experts in their particular fields, joined in the general discussion which followed the reading of the foregoing papers. Several of those present gave interesting and valuable talks.

Complete mimeographed copies of the meeting records will be available at $1 per copy in the near future. These may be obtained by writing to F. D. Snyder, chairman of the Heat Processing Committee, in care of the Westinghouse Electric Corporation, 10 High Street, Boston, Mass.

Western Society of Engineers Elects Officers

THE Western Society of Engineers has announced that Titus G. Leclair, chief staff engineer, Commonwealth Edison Company, has been elected president of the Society for the year, 1946–1947.

Other officers elected were: William V. Kahler, general manager, Illinois Bell Telephone Company, first vice-president; Verne O. McClurg, consulting engineer, firm of Mundie-Jensen-McClurg, second vice-president; M. W. Casad, plant extension engineer, Illinois Bell Telephone Company, treasurer; and Leigh S. Keith, secretary.

The following directors were also elected: J. de N. Macomb, assistant to vice-president, Inland Steel Company, and Henry Penn, district engineer, American Institute of Steel Construction.

Harold B. Maynard Elected President of S.A.M.

HAROLD B. MAYNARD, associate member, A.S.M.E., president, Methods Engineering Council, has been elected national president of the Society for the Advancement of Management for 1946-1947.

Other officers elected were: William L. McGrath, The Williamson Heater Company, Cincinnati, Ohio, vice-president; Franklin E. Folts, Harvard Graduate School of Business Administration, secretary; and Allen H. Ottman, American Hard Rubber Company, New York, N. Y., treasurer.

HEATING PROCESSING COMMITTEE OF THE A.S.M.E. TEXTILE DIVISION

Standing, left to right: J. S. Merigold, Wilksonville, Mass.; J. H. Hamilton, Pepperell Manufacturing Company, Lewiston, Me.; C. E. Brown, De-Walt Machinery and Engineering Company, Worcester, Mass.; G. F. Belforti, Draper Corporation, Hopedale, Mass.; William Stewart, American Woolen Company, Kennebec Mills, Fairfield, Me.; Frank C. Thurston, Guilford Woolen Mills, Guilford, Me.; C. E. Center, Westinghouse Electric Corporation, Boston, Mass.; A. L. Park, Saco-Lowell Shops, Biddeford, Me.; Harry Brook, Saco-Lowell Shops, Biddeford, Me.; A. W. Ferre, B. F. Sturtevant Company, Hyde Park, Mass.; J. P. Franklin, David Gessner Company, Worcester, Mass.; L. T. Jester, Jr., General Electric Company, Cambridge, Mass.; C. E. Crede, L. N. Barry Company Incorporated, Cambridge, Mass.; Henry Dufries, David Gessner Company, Worcester, Mass.; R. L. Brown, Lowell Textile Institute, Lowell, Mass.; W. G. Agnew, Chicopee Manufacturing Corporation, Chicopee, Mass. *Seated, left to right:* James W. Stanley, American Woolen Company, Kennebec Mills, Fairfield, Me.; F. D. Snyder, Westinghouse Electric Corporation, Boston, Mass.; W. O. Jelleme, Pacific Mills, East Newark, N. J.; Carl D. Brown, chairman, A.S.M.E. Textile Division, Draper Corporation, Hopedale, Mass.; J. D. Robertson, Mt. Hope Machinery Company, Taunton, Mass.; G. D. Godard, General Electric Company, Boston, Mass.; A. B. Studley, SKF Industries, Incorporated, Boston, Mass.)

May Meeting of Boiler Code Committee Held at Absecon, New Jersey

The Boiler Code Committee of The American Society of Mechanical Engineers held its regular May meeting on Friday, May 10, 1946, at the Seaview Country Club, Absecon, N. J. The meeting was preceded by a program of social events on Thursday, May 9, at which the Boiler Code Committee was host to members of its subcommittees and to representatives of city and state enforcement agencies serving on its Conference Committee.

For the first time in many years a regular meeting of the Boiler Code Committee was held away from New York, N. Y.

The program on Thursday consisted of golf and bridge games. These were followed in the evening by a cocktail hour and banquet. The business meeting of the Committee was held the following day.

As the principal social event of the meeting, the banquet, attended by more than fifty engineers many of whom have long been active in the boiler safety movement, marked a milestone in the work of the Boiler Code Committee.

In his welcoming address, H. B. Oatley, chairman, Boiler Code Committee, stressed the importance of co-operation between all groups interested in the boiler and pressure-vessel safety movement. He said that occasions such as this afforded an opportunity for the various individuals in boiler safety work to become better acquainted and that such acquaintance was the keystone of continued smooth functioning of the movement.

C. E. Davies, secretary, A.S.M.E., complimented the members on behalf of the Society and expressed deep appreciation for the service they were rendering to the public and industry.

Gerald Gearon, chairman, National Board of Boiler and Pressure Vessel Inspectors and chief boiler inspector, City of Chicago, spoke briefly on the value of co-operation between the Boiler Code Committee and city and state enforcement agencies.

D. S. Jacobus, honorary chairman, Boiler Code Committee, who has been with the committee since its inception, reviewed the history and past development of the boiler code safety movement in the A.S.M.E.

Although a departure from the regular mode of meetings, a great deal was accomplished and members generally look forward to future meetings on this plan.

Agenda for I.J.C.P.D. Meeting Announced

The thermodynamic properties of moist air has been selected as the first subject for consideration by the International Joint Committee on Psychrometric Data at its next meeting, the date of which has not yet been set.

The I.J.C.P.D. was formed in 1945 under the sponsorship of the American Society of Heating and Ventilating Engineers. The purpose of the Committee is to establish an international standard on the properties of air and water-vapor mixtures and thereby to eliminate the conflicting values which appear in the several tables now used in Canada, Great Britain, and the United States.

The following organizations are participating in the work of the Committee: *Canada*, Meteorological Division, Department of Transport; National Research Council; *Great Britain*, Institution of Heating and Ventilating Engineers; National Physical Laboratory; The Physical Society; *United States*, American Institute of Chemical Engineers; American Physical Society; American Society of Heating and Ventilating Engineers; The American Society of Mechanical Engineers; American Society of Refrigerating Engineers; Weather Bureau; National Bureau of Standards, Department of Commerce; Signal Corps, War Department.

B. A. Dmitrieff, member A.S.M.E., assistant engineer, mechanical-engineering department, Consolidated Edison Company of New York, New York, N. Y., is the A.S.M.E. representative on the I.J.C.P.D.

Steam Power Dominates

Studies by the power committee of the Twentieth Century Fund covered in the report "The Power Industry and the Public Interest" edited by Edward Eyre Hunt show that at the beginning of 1941, 70 per cent of the country's total generating capacity was derived from steam, 28.6 per cent from water power and 1.4 per cent from internal-combustion engines. Although the relative importance of hydroelectric power has increased slightly since 1935, the unused water resources in that year would, if utilized, have increased the national output by nearly 150 per cent.

R. J. S. Pigott Receives Columbia Medal

Reginald J. S. Pigott, past vice-president A.S.M.E., chief engineer, Gulf Research and Development Company, Pittsburgh, Pa. was awarded the Columbia University Medal for Excellence at the 192nd Commencement at Columbia University, New York, N. Y., June 4, 1946.

In making the presentation, Frank D. Fackenthal, acting-president of the University, said, "Reginald James Seymour Pigott, mechanical engineer, whose creative ability and competence in the development and guidance of new ideas has in a long and diverse career resulted in a multitude of improvements in mechanical engineering, it is my pleasure to hand you the University Medal for Excellence."

Correction

To A.S.M.E. Power Test Code for Steam Turbines and Appendix

The attention of the A.S.M.E. Power Test Codes Committee has been called to a number of additional errors and ambiguities that require correction and clarification in the 1941 edition of the Test Code for Steam Turbines and in the 1943 edition of the Appendix to the test code. Errata sheets have been prepared for Par. 191 in the test code covering formulas for the determination of steam flow according to the Enthalpy Drop Method as well as for Section VI of the Appendix on Flow Measurement by the Enthalpy Drop Method.

Copies of these errata have been prepared and may be obtained upon application to C. B. LePage, Secretary to the A.S.M.E. Power Test Codes Committee, 29 West 39th Street, New York 18, N. Y.

Army to Co-Ordinate Military and Civilian Research Projects

Convinced of the need of continued applications of national research facilities to the solution of the military problems of national defense, General Dwight D. Eisenhower, chief of staff, U. S. Army, recently enlarged the Army General Staff organization by the creation of a Research and Development Division.

The new division will be responsible for all War Department activities dealing with research and development and will act as liaison between Army planning chiefs on one hand and the universities and research laboratories on the other. The organization of the division calls for the services of one or more civilian specialists to advise the Army on its projects and to furnish science and industry with first-hand information on the objectives of military planning.

In his directive, General Eisenhower stated that "in order to insure the full use of our national resources in case of emergency," the following general policies would be put into effect:

(1) Civilian assistance would be sought in military planning as well as for production of weapons; (2) scientists and industrialists would be given greatest possible freedom in the conduct of research programs for the Army; (3) if possible, industrial and technological resources would be used as organic parts of military structure during times of emergency; (4) the responsibility for research and development would be separated from the functions of procurement, purchase, storage, and distribution; and (5) all officers would be "oriented" to recognize the advantages to the Army of close integration of civilian talent with Army plans and development.

Colonel Gervais W. Trichel of the War Department Special Staff New Developments Division is serving as acting director of the new division until the Secretary of War selects a director.

J. N. Goodier Wins S.P.E.E. Westinghouse Award

J. N. GOODIER, member A.S.M.E., professor of machine design and head of the departments of machine design and mechanics, Cornell University, Ithaca, N. Y., was presented the Westinghouse Award for notable contributions in engineering education by the Society for the Promotion of Engineering Education at its annual meeting at the Jefferson Hotel, St. Louis, Mo., June 21, 1946.

Dr. Goodier is the first recipient of the Westinghouse Award. The award consists of $1000 and a special certificate. It was established in 1946 to commemorate the 100th anniversary of the birth of George Westinghouse and to honor, annually, the college or university teacher adjudged by the S.P.E.E. to have contributed most to the successful teaching of engineering students.

During the war Dr. Goodier administered special courses in stress analysis and elastic stability to classes at Bell Aircraft Corporation, Buffalo, N. Y., and directed research work on aeronautical projects carried on at Cornell University.

In 1945 he was chairman of the Applied Mechanics Division of the A.S.M.E.

E.E.I. Holds Annual Meeting in New York, N. Y.

THE Edison Electric Institute, one of the principal trade associations of the electric utility industry, held its annual meeting at the Waldorf-Astoria Hotel, New York, N. Y., June 3 to 5, 1946.

Grover C. Neff, president, Wisconsin Power and Light Company, Madison, Wis., was unanimously elected president of the Institute for 1946–1947. With Mr. Neff's election the Institute will return to its former policy of a part-time non-salaried president who will be elected annually.

Mr. Neff succeeded C. W. Kellogg, salaried full-time president of the Institute since 1939, whose retirement on June 30, 1946, terminates a career of 43 years of distinguished service to the electric-utility industry.

During the two-day program of general sessions, authorities in the industry discussed the need for convincing American industry of the advantages of electric-utility power, the wartime developments in the use of electric energy in manufacturing operations, the relation of nuclear-energy developments to the electric-power industry, and the research programs which have been undertaken to improve the utilization of bituminous coal.

Body Engineers Organize

ANNOUNCEMENT has been made of the formation of a new engineering society called The American Society of Body Engineers, Incorporated, by its president, I. Louis Carron, body engineer of the Detroit Harvester Company. The society has been organized as a nonprofit corporation with national headquarters in the Rackham Memorial building in Detroit, Mich. This is an organization composed entirely of leading body engineers from practically all the companies in the automotive industry.

Mr. Carron states that the forerunner of the present-day body engineer was a carriage maker, an artisan who at the turn of the century was capable of designing and building his own carriages. He had to be an artist as well as a first-class woodworker and upholsterer. It was natural for men of these talents to turn to the building of bodies for automobiles. Few of these men were college-trained engineers, and any knowledge of engineering was acquired through practical experience.

Today, a successful body engineer must be well versed not only in the fundamentals of engineering but in addition, must be a good artist.

Recognition of the fact that body engineering has reached the status of a profession is seen in the recent announcement of the University of Michigan that this fall it will start a course in body engineering which will lead to the granting of a degree in engineering.

A technical convention will be sponsored by this society in October, to be held in the Rackham Memorial Building, with Carl W. Cenzer as general chairman. Plans are already well under way. Committees are being formed and are to be headed by capable and experienced men who have devoted many years toward the progress of body design and engineering.

American Arbitration Association

THE American Arbitration Association, New York, N. Y., has recently announced its latest publication entitled "Foreign Trade Arbitration Facilities and Services." It contains the latest clauses and arrangements entered into for the protection of American traders in foreign countries against the difficulties facing them in the settlement of differences under chaotic postwar conditions in many countries.

The American Arbitration Association is a nonpartisan, nonprofit-making, scientific, and educational membership corporation, authorized under a New York Charter for the sole purpose of advancing the knowledge and use of arbitration.

The Association maintains a central headquarters in New York City, and 30 regional offices in various cities throughout the United States.

It maintains a panel of more than 10,000 volunteer arbitrators located in 1848 communities and in other localities where an arbitration is desired by the parties. The Association provides rules of procedure, hearing rooms, administrative and clerical services for these facilities.

The costs are uniform, being set forth in the rules, and are based upon the amount involved and the number of hearings which are required.

The Association is the accepted national agency for all types of arbitration. Its rules of procedure are followed generally.

Belgian Engineers Celebrate Sixtieth Anniversary

ON THE occasion of the sixtieth anniversary of the Belgian engineering society, Societe Royale Belge des Ingenieurs et des Industriels, President D. Robert Yarnall, on behalf of The American Society of Mechanical Engineers, sent the following congratulatory cablegram to M. P. Fontainas, president of the Belgian organization, "Greetings on completion Sixtieth Anniversary. Sincerely hope daily scientific forums arranged to celebrate anniversary were most successful."

In view of the disruption caused by the war, Belgian engineers set aside the national tradition of celebrating only each quarter century of existence. The sixtieth anniversary of the Society was commemorated by a national engineering convention in Brussels, Belgium, May 13 to 19, 1946, during which many technical sessions were held under the general theme, "Five Years of Technical Progress 1940–1945."

Shortage of Young Engineers Until 1949

BASED on the current enrollment of engineering students in the United States and Canada, William B. Plank, department of mining and metallurgical engineering, Lafayette College, Easton, Pa., estimates that the 150,000 postwar deficit of engineers reported by Vannevar Bush, director, Office of Scientific Research and Development, would not be liquidated until the present freshman class graduates in 1949.

Engineering student enrollment in November, 1945, was 73,269. The second semester enrollment was estimated to be about 100,000 students.

Approximately 5000 degrees in engineering were conferred in June, 1946. This number, although greater than in the spring of 1945, is only 30 per cent of the peak number of degrees conferred in 1942–1943.

According to Professor Plank, the number of students registered in November, 1945, in senior engineering classes was as follows: 289 mineral engineers; 748 chemical engineers; 714 civil engineers; 1373 mechanical engineers; 948 electrical engineers; and 898 engineers of other types.

Attendance at 1946 A.S.M.E. Spring Meeting

THE official attendance at the A.S.M.E. Spring Meeting in Chattanooga, Tenn., was 575. Of this number 218 were members, 226 guests, 60 women, and 71 students.

Engineers representing 30 states and the District of Columbia were present. Those from Chattanooga and other industrial centers in Tennessee formed the largest state group with an attendance of 223. Georgia, Metropolitan New York, and North Carolina, each were represented by groups of fifty or more engineers.

A.S.M.E. to Expand Standardization Activities

TO meet the need for new codes and standards, and the revision of existing ones, the A.S.M.E. plans to extend its activities in this field by enlarging the secretarial staff of the A.S.M.E. Technical Committees.

Handicapped during the war by lack of staff, the A.S.M.E. Technical Committees were compelled to restrict their activities to meet the more essential requirements of wartime production. As a result, important work reluctantly postponed, remains on the agenda of the Technical Committees. Manufacturing experience prior to and during the war indicated the need for many new codes and standards, and technical progress has created a pressure for revision of many existing ones.

In a plan proposed by Howard Coonley, chairman of the A. S. M. E. Board of Codes and Standards, it was suggested that the secretarial staff of the Technical Committees be enlarged by three members and that the cost of an intensified program could be met by the following measures: (1) Increasing the selling price of new and revised codes and standards 10 to 20 per cent; (2) using the additional income that may be expected to accrue from increased production. The Executive Committee of the Council at its May, 1946, meeting approved the proposal of the Board of Codes and Standards.

Midwest Research Institute Expands Services

IN line with its continuously expanding program, the Midwest Research Institute, Kansas City, Mo., has recently announced the formation of its Engineering Mechanics Section. Previously, work in this field was done under supervision of the Applied Physics Section.

Martin Goland, junior member A.S.M.E., formerly of the structures department of the Curtiss-Wright Research Laboratory, Buffalo, N. Y., has been appointed chairman of the new section.

Clayton O. Dohrenwend, member A.S.M.E., formerly chairman of the mechanics department at the Illinois Institute of Technology and the Armour Research Foundation, will serve as research consultant and senior scientist.

1944 Oil Engine Power Cost Report

FOR those concerned with problems of economic power supply for industrial plants this report presents information on performance and production costs of Diesel oil-engine power plants. It also provides accurate information on the cost of fuels, lubrication, attendance and superintendence, supplies and miscellaneous, engine and all other plant repairs.

The report includes information from 121 oil-engine generating plants, containing 364 engines, totaling 274,348 rated bhp, with a total net output of 418,170,348 kwhr.

Copies of the report may be purchased by addressing the A.S.M.E. Publication Sales Department, 29 West 39th St., New York 18, N. Y.

Social Effects of Aviation to Be Studied by New Organization

LEADERS in engineering, business, and education with the co-operation of government officials have organized an international project to study and predict the effects of aviation on the social institutions of the world.

The project, organized on a global basis, is called Air Affairs, Incorporated, and has for its main objective the publication of the "*International Journal of Air Affairs.*" The first issue of the quarterly journal was published in June, 1946.

Charles F. Kettering, vice-president, General Motors Corporation, member A.S.M.E.; Edward Warner, president, Provisional International Civil Aviation Organization, member A.S.M.E.; and Ralph S. Damon, president, American Airlines, Inc., member A.S.M.E., are among the 100 individuals and 40 companies throughout the world, who are charter members of Air Affairs, Inc.

As a scholarly journal, the "*International Journal of Air Affairs,*" will carry the views and researches of air experts from all parts of the world. The editorial and executive offices of the journal are located at 1829 G Street, N. W. Washington, D. C. Annual subscription is $5.

Towing Tank Fellowships Established by Stevens Institute

THE Experimental Towing Tank, Stevens Institute of Technology, has announced the establishment of several fellowships for graduates of engineering colleges who are interested in learning the techniques of model tests of ships and flying-boat hulls.

Each fellowship will be for one year, and possibly for two years, and will pay from $150 to $250 monthly, depending on the educational background of the applicant.

Additional information may be obtained by writing to Prof. John P. Fife, director of personnel, Experimental Towing Tank, Stevens Institute of Technology, Hoboken, N. J.

S. C. Hollister Elevated by Cornell University

S. C. HOLLISTER, dean, college of engineering, Cornell University, Ithaca, N. Y., has been appointed vice-president of Cornell University. He will fill a new post created by the Board of Trustees.

Dean Hollister will continue as head of the college of engineering after assuming his new administrative duties. As vice-president of Cornell University, he will be in charge of University development.

A.I.S.E. Annual Convention to Be Held Oct. 1–4, 1946

THE Iron and Steel Exposition, sponsored by the Association of Iron and Steel Engineers, will be held in the Cleveland Public Auditorium, Cleveland, Ohio, October 1 to 4, 1946. The exposition will be held in conjunction with the 1946 annual convention of A.I.S.E.

More than 150 manufacturers who supply equipment and services to the nation's iron and steel, metalworking, and allied industries, are expected to exhibit their products.

Escalator Clauses Concern of Public Works Contractors

ECONOMY in construction of public works and the need for a suitable escalator clause for public-works contracts to minimize the hazard of unpredictable costs in bidding were topics discussed by the Public Works Construction Advisory Committee at a meeting which was held at the Federal Works Building, Washington, D. C., May 28, 1946.

For his initiative in developing escalator clauses for use in government construction contracts, Philip B. Fleming, major general, U. S. Army, administrator of the Federal Works Administration, received a vote of appreciation from the Committee.

Other topics discussed were the status of the federal highway construction program and the available funds for the continuation of the Federal Works Administration planning program.

Marion X. Wilberding, president, Wilberding Company, Washington, D. C., is the A.S.M.E. representative on the Public Works Construction Advisory Committee.

J. E. Lovely Appointed to the A.S.A. Board of Directors

JOHN E. LOVELY, member A.S.M.E., vice-president, Jones and Lamson Machine Company, Springfield, Vt., has been appointed to the Board of Directors of the American Standards Association.

Mr. Lovely has been an active participant in standardization work for many years. As official A.S.M.E. representative he is serving at the present time as chairman of the A.S.A. sectional committee on Allowances and Tolerances for Cylindrical Parts and Limit Gages (B4) and as member on two other A.S.A. committees. He has recently relinquished his position on the A.S.A. Standards Council, which he held for three years.

Sections

New Haven Is Host at Meeting of Connecticut Sections

MORE than 200 members and guests of the Connecticut Sections of The American Society of Mechanical Engineers and the Connecticut Technical Council enjoyed an all-day program of golf, visits to New Haven's art, historical, and research institutions, and later attended a dinner at the New Haven Lawn Club, New Haven, Conn., May 25, 1946, as guests of the New Haven Section of the A.S.M.E.

The program was the first postwar meeting of the Connecticut Sections of the A.S.M.E. and marked the continuation of the custom established fifteen years ago as a means of cultivating the co-operation of Connecticut industry in the work of the Society.

Harry R. Westcott, president, Westcott and Mapes, Inc., served as toastmaster at the dinner. Following an address of welcome by A. S. Redway, vice-president, Geometric Tool Company, chairman, New Haven Section, A.S.M.E., Mr. Westcott introduced Alton C. Chick, vice-president A.S.M.E. Region I, who made a brief report on the administrative changes of the Society and the progress that had been made in the establishment of the Regional Administrative Committee.

A.S.M.E. Secretary Speaks

Left to right: FRANK W. PRESTON, CHAIRMAN OF THE GENERAL COMMITTEE AND ALTON C. CHICK, VICE-PRESIDENT A.S.M.E. REGION I, AT THE 1946 ANNUAL MEETING OF THE CONNECTICUT SECTIONS

C. E. Davies, secretary A.S.M.E., was the principal speaker of the evening. Mr. Davies spoke on the subject, "Whither Engineers?" He said that engineering principles and scientific methods could be used to alleviate some of the problems that beset the country today, and that information about nuclear energy should be made public so that engineers could apply their talents to the application of this new source of energy in a beneficial way.

Commenting on Mr. Davies' talk, Mr. Westcott said, "The stimulus given engineering by the war, the tremendous development in organized research, and the nation's reconversion plans offer opportunities for engineers not previously dreamed of."

"But with price controls, the harnessing of atomic energy, international confusion, and labor problems" he continued, "today's engineers must look to men like Mr. Davies, who are in close touch with national developments, for answers to many of their current problems."

As part of the evening's program two sound color films were shown. The first was "Modern Living," by the Westinghouse Electric Corporation, which showed how the use of electricity in the postwar home could help create a new order of comfort and convenience.

The second film was "Jet Propulsion," by the Bell Aircraft Corporation. Both films were thoroughly enjoyed.

Committee

Serving on the general state committee for the event were William E. Hogan, Sikorsky Aircraft Corporation, Bridgeport; Richard D. Keller and Earl R. Lewis, Jr., both of Pratt and Whitney, Hartford; L. A. Lachman, Atwood Machine Company, and Prof. Karl P. Hanson, New London; J. Heartt Raub, Waterbury Farrel Foundry and Machine Company; and Thomas M. Rianhard, Chase Brass & Copper Company, Waterbury; Frank W. Preston and A. S. Redway, of New Haven, and Bronis R. Onuf, University of Connecticut, Storrs, Conn., secretary-treasurer of the New Haven Section.

G. H. Eaton, Foskett and Bishop Company, New Haven, served as chairman of the committee on reception and registration, and the committee members were William H. Sniffen, Norwalk Company, Inc., South Norwalk; Richard L. Wail, Colt Patent Firearms, Hartford; L. A. Lachman, New London, and Thomas Rianhard, Waterbury.

In addition to Frank W. Preston, chairman, the New Haven committee on arrangements

SPEAKERS' TABLE AT THE 1946 ANNUAL DINNER OF THE CONNECTICUT SECTIONS AT THE NEW HAVEN LAWN CLUB, MAY 25, 1946 included C. W. Taylor, Westcott and Mapes, Inc.; Michael J. Radecki, Henry G. Thompson and Son Company; Gustave Welter, Bigelow and Company; Charles W. Phelps, Yale University; H. D. Fisher, and Willis F. Thompson, Westcott and Mapes, Incorporated, and Roy L. Parsell, Winchester Repeating Arms Company, division of Olin Industries, Inc., who had charge of publicity.

Boiler Feed Pump Symposium at Anthracite-Lehigh Valley Section

A SYMPOSIUM on boiler feed pumps was the feature of the April 26 meeting at the Penn-Stroud Hotel, Stroudsburg, Pa. Four speakers covered very completely the subject of corrosion-erosion control in centrifugal boiler feed pumps. Particular stress was laid on the effect of pH value of water pumped upon the various materials, and the buffering effect of stabilizing pH value where feedwater with high dissolved-solids content is used. In central-station work it appears that steel alloys with 5 per cent or more chromium successfully combat corrosion. The speakers and their papers were: J. B. Godshall, metallurgist, Ingersoll-Rand Company, "Feedwater and Its Treatment;" R. J. Allen, chief metallurgist, Worthington Pump and Machinery Company, "Metallurgy of Boiler Feed Pumps;" H. G. Gartmann, member A.S.M.E., chief engineer, pump and compressor department, DeLaval Steam Turbine Company, "Application, Installation, and Operation;" and Hugh Platt, engineer in the eastern district of Byron-Jackson Company, "Maintenance of Boiler Feed Pumps."

A dinner preceded the meeting. One hundred and twenty-eight were present at the symposium.

The meeting on May 24 at the Hotel Altemont, Hazleton, Pa., featured a talk on "Selection of Steels for Fabrication," by Dr. W. G. Theisinger of Lukens Steel Company. Dr. Theisinger outlined the economic reasons for the selection of a given-width plate for tank and pressure-vessel fabrication, basing his conclusions on the results of a survey of over 200 fabricators. He also covered the use of steel plate clad with various others metals, the economics, and the method of manufacture.

The talk was illustrated with pictorial and graphical slides. Forty members and guests were present.

Battelle Memorial Research Engineer Speaks at Atlanta Section

On May 27 a dinner meeting was held, followed by a lecture in the Chemistry Building, Georgia School of Technology, Atlanta, Ga. The speaker, W. J. King, research engineer at Battelle Memorial Institute, Columbus, Ohio, spoke on "Modern Developments of Engines and Power Plants." The audience of 100 engineers and students greatly enjoyed hearing Mr. King, who is engaged principally in research on heat engines and liquid fuels.

CHAIRMEN OF THE CONNECTICUT SECTIONS OF THE A.S.M.E. AT THE ANNUAL MEETING IN NEW HAVEN, CONN.

(*Left to right:* Karl P. Hanson, New London, Section; W. E. Hogan, Bridgeport Section; T. M. Rianhard, Waterbury Section; Thomas F. Cassidy, Jr., Hartford Section; and A. S. Redway, New Haven Section.)

"Aviation Gas Turbines" Talk at Central Pennsylvania Section

On May 8 at Pennsylvania State College, State College, Pa., C. D. Flagle, junior A.S.M.E., Westinghouse Electric Corporation, spoke on "Aviation Gas Turbines." Mr. Flagle gave general statements for the need of this form of prime mover; the advantages and disadvantages of the turbine over the conventional form of power; general performance data in regard to fuel consumption, speed and height, and discussed metallurgical limitations and possible methods of correction. Two hundred members and guests were present.

Prof. J. Ormondroyd Speaks at Chicago Section Dinner Meeting

On May 8 a dinner meeting was held in the Student Union Building, Illinois Institute of Technology, sponsored by the Applied Mechanics Division of the Chicago Section A.S.M.E. and Mechanics Colloquium. The speaker was Prof. J. Ormondroyd, member A.S.M.E., professor of mechanical engineering, University of Michigan, whose talk was entitled "The Interpretation of Records of Motion-Measuring Instruments." Professor Ormondroyd spent many years at Westinghouse Electric Corporation in general research work, and at the David Taylor Model Basin on vibration measurement. The latter work consisted of setting up of homemade instruments for the measurements of mild vibrations such as the floating of a battleship, and also that of violent vibrations such as firing of a 16-inch gun. All work along this line has been exploratory to date and is a wide-open field for a great deal of research in the future. There were 85 at dinner and 105 at the lecture.

Cincinnati Section Holds Annual Meeting

On May 23 at the Maketewah Country Club, Cincinnati, Ohio, golf was played in the afternoon, followed by dinner and program which featured Prof. S. R. Beitler, vice-president, A.S.M.E. Region V, who spoke on "Local and National A.S.M.E. Activities." This was the annual meeting of the Section, when officers for the coming year are installed. The evening was also designated "Past-Chairmen's Night." Twelve past-chairmen, including the retiring chairman, M. Martellotti, were present, as well as the new officers and newly elected members of the Section's executive committee. Fifty-six members were at dinner and 75 attended the session.

"Gun-Fire Control" Topic at Cleveland Section

At the meeting on May 9 in the Cleveland Engineering Society Building, Cleveland, Ohio, Macon Fry discussed, under the title "Gun-Fire Control," the mathematics and mechanics of calculating and computing mechanisms. Thirty were present.

Colorado Section Holds Joint Meeting With Rocky Mountain Student Branches

On May 3 at the Oxford Hotel, Denver, Colo., F. K. Floyd of the Metron Instrument Company, gave a talk on "New Ideas in Measuring Instruments." The speaker demonstrated the comparator gage and also the electric tachometer manufactured by his company. He outlined in an interesting manner some of the many problems involved in the production and sale of these instruments. This was a joint meeting with the student branches of the Rocky Mountain region, assembled for their spring conference. Forty-three members and 26 guests were present.

The officers elected for the 1946–1947 season are: J. F. Ransom, chairman; A. A. Woodward, vice-chairman; J. Y. Parce, secretary-treasurer; J. T. Strate, two-year term on executive committee of the Section.

General H. R. Kutz Speaks at Detroit Section

At the meeting on May 17 at the Rackham Memorial, Detroit, Mich., Gen. H. R. Kutz addressed the Section on "Training for Leadership." Approximately 100 followed with great interest the speaker's thought-provoking and stimulating talk. A discussion period, lasting an hour, followed.

"Jet Propulsion" Described at Ithaca Section

On May 21 at the Baron Steuben Hotel, Binghamton, N. Y., Prof. C. W. Terry, Cornell University, spoke on "Jet Propulsion." Professor Terry's description of flight tests of Consolidated B24 and B32, and his work on jet propulsion at the Ryan F.R.I. were illustrated by a Bell Aircraft sound movie, "Report on Jet Propulsion." There were 52 at the meeting.

"Developments in Balancing Machines," Discussed at New London Section

On May 15 at the Mohigan Hotel, New London, Conn., the subject was "Recent Developments in Balancing Machines." F. R. Bokorney of the Gisholt Machine Company, gave the talk and proved to be an interesting and entertaining speaker. Mr. Bokorney explained that balancing is important because of the tremendous amount of rotating machinery in everyday use. Without balancing the vibration and noise of such machinery would be objectionable. He said that from a strictly technical standpoint a rotating element is out of balance when the axis of rotation does not correspond with one of the principal axes of inertia of the rotor, that is, the weight of the rotating element is not uniformly distributed, either axially or radially, about the center of the rotations of the rotor. By applying two correction weights to the rotor all cases of unbalance may be corrected. The talk was illustrated with slides showing various machines and methods used in the process.

Philadelphia Section Has Annual Outing

THE annual outing of the Section was held on the afternoon and evening of May 28, 1946, at Cedarbrook Country Club. Some 74 hardy spirits refused to be discouraged by misty weather and entered into competition for the various golf trophies. Others, including most of the ladies, indulged in bridge or were content to renew old friendships. Dinner was served to a record crowd of 320. Retiring section chairman Justin J. McCarthy introduced the guests of honor, D. Robert Yarnall, president A.S.M.E., and Mrs. Yarnall. Following brief remarks by President Yarnall, chairman McCarthy thanked the other local officers for their co-operation during his term and then turned over the gavel to his successor, Sidney T. MacKenzie. Mrs. Frank W. Miller, chairman of the Philadelphia Women's Auxiliary for two years, introduced the incoming chairman, Mrs. Burton F. Keene.

SIDNEY T. MACKENZIE, CHAIRMAN, PHILADELPHIA SECTION A.S.M.E., RECEIVES GAVEL FROM JUSTIN J. MCCARTHY, RETIRING CHAIRMAN

After the speaking program, golf trophies and door prizes were awarded. The tables were then cleared away for a vaudeville show and dance, which continued to the wee sma' hours. The affair had every indication of a howling success.

Film on "Wrought Iron" Shown at Providence Section

On May 7 in the Providence Engineering Building, Providence, R. I., a sound movie entitled "Wrought Iron" was shown. This was a film made by A. M. Byers Company, illustrating the history, manufacture, and application of wrought iron. Robert Law, the speaker of the meeting, supplemented verbally the film's story, and conducted the question period which followed. Sixty members and guests were present.

"Electronics in Peace and War" Talk at St. Joseph Valley Section

On May 22 at the Oliver Hotel, South Bend, Ind., Gordan Volkenant, Minneapolis-Honeywell Company, spoke on "Electronics in Peace and War." This meeting was held with the co-operation of the Engineers Club of St. Joseph Valley and the National Association of Power Engineers. Mr. Volkenant told of how electronics played a hitherto unpublished part in the Allied bombing program and discussed many of the peacetime uses of electronics. The attendance totaled 225.

Schenectady Section Hears Lecture on "Appearance Design"

A meeting was held on May 22 in Old Chapel, Union College, Schenectady, N. Y., which featured a talk on "Appearance Design," by Alan Tompkins, appearance design division, General Electric Company. Mr. Tompkins traced the progress of appearance design from ancient times to the present. He outlined some of the principles and philosophy of appearance design, and showed a number of slides illustrating the great improvement in the appearance of many products which resulted from designing for appearance as well as utility. An audience of 60 enjoyed the lecture.

River Valley Development Topic at Southern Ontario Section

A meeting was held on April 11 in Hart House, University of Toronto, Toronto, Can., sponsored by the junior group, of which Grant Huber is chairman. A. H. Richardson spoke on "River Valley Development in Southern Ontario." Mr. Richardson discussed the river valley conservation as a means of providing flood control, elimination of top-soil erosion, conservation of wild life, and provision for good recreational facilities for Ontario residents and visitors. His talk was illustrated with kodachrome slides. Forty-five were present.

MRS. FRANK W. MILLER, RETIRING CHAIRMAN, WOMAN'S AUXILIARY, PHILADELPHIA SECTION, A.S.M.E. HANDS GAVEL TO MRS. BURTON F. KEENE, CHAIRMAN

HEAD TABLE AT THE SAN FRANCISCO ENGINEERING COUNCIL JOINT MEETING AT THE ENGINEERS CLUB, SAN FRANCISCO, CALIF., MARCH 13, 1946
(*Standing, left to right:* Major Lyman, Messrs. Adrian, Prescott, Stern, Parsons, Becker, Howard. *Seated, left to right*, Messrs. Baugh, Ready, Avery, Reid, Dresser.)

Utah Section Has Joint Meeting With A.I.E.E. and A.S.C.E.

A joint meeting with the A.I.E.E. and A.S.C.E. was held on March 20 in the ballroom of the Newhouse Hotel, Salt Lake City, Utah.

Dr. A. Allan Bates, who is manager of chemical and metallurgical department research laboratories, Westinghouse Electric Corporation, Pittsburgh, Pa., spoke on "War and Peace as a Scientist Sees Them." Dr. Bates was the only metallurgist to serve in Germany with an army "scientific commando" unit that captured and questioned many of the Reich's leading scientists, securing information on their development of atomic power, radar, and other important weapons of war. In his talk Dr. Bates said that in his opinion a large peacetime conscript army would be as useless as a Maginot Line for it would "announce to the world that we intend to indoctrinate our entire youth with military ideas, thus leading to a final atomic armaments race that will end in complete destruction of all nations." Dr. Bates said that "instead, to keep our nation strong and at the same time assume world leadership for peace, we should keep our scientific research and development at a high level of efficiency, and we should keep it free." He advocated that pure or fundamental research be left to the educational and industrial organizations of the country, and that the government assume leadership in maintaining and establishing development plants, aviation test fields, and military development laboratories.

The Section agreed that Dr. Bates was one of the finest speakers they had had the privilege of hearing. About a hundred were in attendance.

On April 17 in the Union Building, University of Utah, Dr. G. Homer Durham, lecturer, political science, University of Utah, spoke on "Labor and American Government and Politics." He gave a résumé of past American politics from 1930, and reviewed labor's gradual rise to power up to and from the passing of the Wagner Labor Act. A discussion period followed. It was the consensus of opinion that this was one of the finest lectures heard by the Section this season.

As a follow-up to Dr. Durham's lecture, "Labor's Point of View" was the topic at the May 1 meeting in the University of Utah Union Building. V. G. Jones, director of District 39, United Steel Works of America, was the speaker. He presented very capably the point of view taken by labor and explained what labor is endeavoring to accomplish. Mr. Jones said that labor's main object is a "decent wage" and standard of living for the worker.

An interesting discussion period followed. Twenty-two were present.

Annual Ladies' Night at Waterbury Section

At the University Club, Waterbury, Conn., on May 10, Miss Lillian Fletcher, assistant director of public relations, Northeast Airlines, gave an entertaining and interesting talk entitled "Housekeeping at 10,000 Feet." She told of her experiences as an air-line hostess and of the many problems that have to be handled. She also explained the requirements demanded by a good commercial air line in picking and training women for this work. This was a dinner meeting, and Annual Ladies' Night of the Section.

Western Mass. Section Meets With Engineering Society of Massachusetts

The Section met with the Engineering Society of Western Massachusetts on May 28 in the Hotel Kimball ballroom, Springfield, Mass. This was also the 27th Annual Ladies' Night of the Engineering Society. After dinner the speaker of the evening, Dr. A. R. Stevenson, Jr., vice-president A.S.M.E., Region III, of the General Electric Company, Schenectady, N. Y., gave a talk entitled "You Are Never Too Old to Learn."

Western Washington Section Holds Joint Meeting

On May 29 a joint meeting of the Western Washington Section and the University of Washington student branch was held at the Faculty Club, University of Washington Campus.

The following student papers were presented: "The Hay Drier, A Special Problem in Heating and Ventilating," by William E. Meneley; "Tests of Postwar Gasoline," by Harry L. Pratt; "Study of Design and Manufacture of Pressure Gages," by Robert G. Hunter; and "Cold Treatment of Steel," by Richard H. Brown.

"Tomorrow's Locomotives" Talk at West Virginia Section

On May 28 at the Daniel Boone Hotel, Charleston, W. Va., R. Tom Sawyer, member A.S.M.E., American Locomotive Company, Schenectady, N. Y., gave a talk on "Tomorrow's Locomotives." Mr. Sawyer included in his talk such developments of significance as Yellott's coal-burning gas-turbine experiments. One hundred and ten members and guests enjoyed hearing Mr. Sawyer.

Worcester Section Hears A. R. Stevenson, Jr.,

"You Are Never Too Old to Learn" was the subject at the May 9 meeting held at Worcester Polytechnic Institute, Worcester, Mass. The speaker was A. R. Stevenson, Jr., vice-president, A.S.M.E. Region III. Dr. Stevenson's theory is that one must keep waking up by finding new things to learn. He stressed the need for adult education among engineers, and gave examples of the way this is accomplished at the General Electric Company where he is staff assistant to the vice-president. He also emphasized the need of creative as well as analytical engineering. He stated that men must learn to be leaders, and quoted his company's motto, "Its not enough to be right, you must be able to persuade." Dr. Stevenson added that education in cultural things leads men to greater heights in their own line of work.

The following members were elected for the year 1946-1947: Fred E. Bailey, chairman; Carroll C. Tucker, vice-chairman; Raymond Tolman, secretary-treasurer; Eric Smith, R. L. Rougemont, Harry F. Ritterbusch, Russell Wood, and Warren Snow, executive committee members.

A.S.C.E. to Meet in Kansas City, Mo.

THE 1946 Fall Meeting of the American Society of Civil Engineers will be held in Kansas City, Mo., Oct. 16 to 19, 1946. Technical sessions will be held at which water supply, sewage disposal, highways, airports, and city-planning problems will be discussed.

Political Careers for Engineers Urged

SUGGESTING that there is need for engineering talent among the nation's politicians, Representative Carl Hinshaw, member A.S.C.E., congressman from Pasadena, Calif., urged engineers to serve the people directly, rather than to continue "servants of the servants of the people" as they are now doing by providing the technical knowledge in various governmental undertakings. Representative Hinshaw, who is himself an engineer, spoke at the annual spring meeting of the American Society of Civil Engineers, Bellevue-Stratford Hotel, Philadelphia, Pa., April 17, 1946.

"Too often, the engineer, like other good citizens," Mr. Hinshaw said, "will cuss the politicians, and yet accept service under them. Why cuss the politician? He is only a man who was willing and able to stand the gaff to achieve public office. The reason why the ordinary garden variety of politician achieves public office is because better-equipped men shirk their responsibilities as citizens and do not offer themselves."

Because of his "highly trained hand, resourceful mind, and inherent integrity," Mr. Hinshaw stated, the engineer in politics could "run interference for the advancement of the welfare of society" by using his special talents to avoid waste, distinguish between the useful and the "hair-brained" idea, and sway public opinion toward practicable projects.

A.S.T.E. Holds Annual Meeting and Exposition

THE Annual Meeting of The American Society of Tool Engineers and the "New Era" exposition, held in Cleveland, Ohio, the week of April 8, 1946, marked the fourteenth milestone in the growth of this organization. The full attendance at the technical sessions and a reported attendance of 12,000 at the exposition for a single day, Wednesday of that week, testifies to the importance attached to tool engineering by industry.

Postwar trends were indicated by papers presented on such subjects as tooling for permanent molds for glass, rubber, and plastics. A paper by A. H. d'Arcambal of Pratt and Whitney, on the precision tools and gages in Germany during the war, and another on British tool engineers by E. W. Hancock, England, gave some insight as to what is going on in other countries.

Other papers varied in subject matter from plant layout to tool engineering and profits. Throughout the meeting emphasis was placed on the importance of the tool engineers in industry. Increased production costs necessitate better machines and machine tools, both of which depend on intelligent design.

The modern trend in tool design was demonstrated at the exposition. Tools and equipment developed under war emergency for high production are now available to industry in general. Special equipment to adapt standard machines to special purposes was much in evidence.

An innovation at the exposition was the introduction of rest islands at a number of points. Equipped with comfortable chairs, these furnished a welcome relief to visitors unaccustomed to being on their feet for hours at a time.

The meeting of the A.S.T.E. was climaxed by the annual dinner at which the officers for the year were installed. George T. Christopher, president, Packard Motor Car Company, was the speaker. He said that attention to product specification, continued improvement of product, and unswerving maintenance of brand reputation were the controlling factors of industry and that these factors depended largely on the tool engineer. Mr. Christopher emphasized the need for the return of industry to a basis of profit incentive as a means of increasing production.

A. M. Sargent, Pioneer Engineering Company, Detroit, Mich., formerly first vice-president, was installed as president for the coming year, and R. B. Douglas, of Montreal, Quebec, Can., was named national secretary of the society.

In place of the traditional wooden gavel, the incoming president was presented with a cemented-carbide gavel and hardened steel striking plate. A light blow by the gavel is said to produce a loud and impressive ring from the plate.

O. W. Eschbach to Receive Octave Chanute Award

OVID W. Eshbach, dean, Northwestern Technological Institute, has been chosen to receive the Octave Chanute Medal for the year of 1945 from the Western Society of Engineers. Formal presentation of the medal will be made at a later date.

The Chanute Medal is awarded each year for the best papers on various engineering subjects presented before the Western Society of Engineers. Dr. Eshbach's prize-winning paper was on postwar engineering education. The Chanute Award was founded in 1901 by the late Octave Chanute during his term as president of the Western Society of Engineers.

New Laboratory Established by University of Texas

A NEW laboratory, known as the Defense Research Laboratory, has been established by the University of Texas, Austin, Texas. The laboratory will investigate fundamental problems relating to certain forms of guided missiles under contract with the Bureau of Ordnance.

C. P. Boner, professor of physics, University of Texas, has been appointed director. M. J. Thompson, member A.S.M.E., professor of aeronautical engineering, is serving as associate director.

Two University buildings, formerly used as athletic dormitories, have been reconditioned and extended to house the laboratory.

The following members of The American Society of Mechanical Engineers are serving as staff members: M. J. Thompson, M. V. Barton, Dana Young, B. E. Short, H. E. Brown, and M. L. Begeman.

Student Branches

University of Akron Branch

At the meeting on April 3 a discussion was held on papers to be presented at the May meeting of the Canton-Youngstown Section, A.S.M.E., for which prizes will be given. The speaker was E. V. Martin, member A.S.M.E., of the Firestone Tire and Rubber Company. His subject was "Engineering as I Have Found It."

University of Cincinnati Branch

A meeting was held on May 29 in the Student Union Building. Guests were welcomed by the chairman, R. E. Lippert, and Professor Bunting, head of the mechanical-engineering department, made some brief remarks about the A.S.M.E. The program consisted of an excellent color motion picture on the manufacture and characteristics of "Formica." The film showed the different processes involved in the making of the product, and a number of its many uses.

Colorado A.&M. College Branch

The meeting on April 8 held in the mechanical engineering building, had as the program a movie entitled "The Inside Story," which gave the fundamentals of correct lubrication. The president gave a report of the plans for the sectional meeting of A.S.M.E. to be held at Colorado University and Denver.

On April 22 a paper was read by student Martino on the manufacturing of paper. A discussion period followed.

University of Connecticut Branch

On April 18 H. E. Edgerton gave a talk on "High-Speed Photography," and at the meeting on May 2 W. Grove spoke on "Bridge Engineering."

Two inspection trips were made—one on April 22 to the United States Finishing Company, Norwich, Conn.; the other on May 6 to the Terry Steam Turbine Company, Hartford, Conn.

Cornell University Branch

The regional meeting at Rhode Island State College May 3–5 was attended by the new honorary chairman of the branch for the coming year, Mr. Mabie. Vice-chairman Randall Johnson and secretary Jarman Kennard were also present. The visitors were conducted on an inspection trip through the college. At the banquet five student papers were presented for which prizes were given.

At the meeting on May 16 in Sibley Hall, H. P. Gray, president of Gray Manufacturing Company, Syracuse, N. Y., gave a very interesting talk on "Precision Casting by the Process of Investment Molding." Fifty members and guests were present.

The May 21 meeting in Room 2, Sibley Hall, presented an illustrated talk by Otto de Lorenzi, member A.S.M.E., director of education, Combustion Engineering Company, Inc., who told of what his company has been doing in the line of boiler manufacture. The color film which ran about forty minutes was noteworthy.

Georgia School of Technology Branch

On April 9 the meeting was called to order by Bill Scott, vice-president. Various members who attended the A.S.M.E. Spring Meeting in Chattanooga, Tenn., the first week in April, gave short reports on different phases of the meeting. Col. L. F. Zsuffa, member A.S.M.E., head of the public relations department, Georgia Tech., then addressed the meeting. He explained the necessity and advantages of junior and senior mechanical engineers joining the branch. He brought up the plan for the re-establishment of Engineers's Day, and gave an interesting history of its founding in various colleges throughout the country, stressing the advantages of such a day at Georgia Tech. The meeting of April 16 was given to Colonel Zsuffa for the planning of Engineer's Day.

The program on April 23 was an all-afternoon field trip to The Southern Machinery and Metals Exposition, held at the Atlanta Municipal Auditorium. The collection of pamphlets and other free literature made by the Tech students could quite easily have filled a library.

On April 30 an interesting picture by the Ford Motor Company was shown, depicting the manufacture of the B-24 Liberator.

Wm. H. Wilkerson, president of The Auto-Solder Company, Atlanta, Ga., was the speaker at the meeting on May 7. Mr. Wilkerson gave an interesting talk on "The South's Need for Industry," explaining the reasons, economic and otherwise, why the South should and could become more industrialized. With the aid of slides the speaker showed the evolution of The Auto-Solder Company from the time that an invention led to the forming of the company in 1932 to the present day.

Illinois Institute of Technology

On March 22 the second meeting of the new semester was called for the purpose of increasing the membership. A group of faculty members of the mechanical-engineering department were invited to attend and speak on membership in the A.S.M.E. These included Dr. J. T. Rettaliata, junior A.S.M.E., head of the mechanical-engineering department; Prof. S. E. Winston, member A.S.M.E., dean of the evening division, and former head of the mechanical-engineering department; Prof. H. L. Nachman, member A.S.M.E., secretary and treasurer of the Chicago Section A.S.M.E.; Prof. D. Roesch, member A.S.M.E., and Prof. R. A. Budenholzer, junior A.S.M.E., The motion to charge dues of $1 per semester was passed. This money will be used for movies and trips in which the branch will participate. Professor Budenholzer, honorary chairman, reminded the members of the conference to be held at the University of Notre Dame.

The meeting on May 17 in the auditorium featured a talk "Have You Got What It Takes?" by Dr. Harold W. Roupp, pastor of the Central Church and chaplain of I.I.T. Dr. Roupp has been associated with many colleges and universities, including the University of Berlin, and Oxford University. He studied engineering at Carnegie Institute of Technology. In his talk he stressed the points necessary to make a new world which are: integrity and courage; good will and faith; and a capacity to stick it out, known as perseverance.

On May 24 plans were discussed for a trip to the South Works of the Carnegie Illinois Steel plant. Those elected for the new semester starting in September were: Robert E. Bevar, president; William R. Weatherby, vice-president; Kurt R. Kuhnle, secretary; and Kenneth Mortimer, treasurer.

Iowa State College Branch

The meeting on April 18 in Room 209 Engineering Hall was called to order by Roger Bowden, president. The following appointments were made for the College Veishea: Floyd J. Stanek and Richard Dove, float committee; Robert Burgan and Richard Saxon, program committee.

On May 2 the name of Derry Williamson was added to the float committee for the College Veishea. Floyd J. Stanek, chairman of the float committee, and Robert Burgan, chai man of the program committee, read their reports.

University of Kansas Branch

A special meeting was held on April 26 when 26 members of the Kansas City Section A.S.M.E., 4 delegates from Topeka, Kan., 6 delegates from Kansas State College, Manhattan, Kan., and 15 mechanical-engineering students on Mt. Oread were honored with a buffet supper by the active and faculty members of Kansas University's student branch. Prof. E. S. Gray, member A.S.M.E., head of mechanical engineering, was toastmaster. The supper was held in the mechanical engineering laboratory. Following supper, the laboratory was formally dedicated, and a bronze plaque, unveiled by Jacob Rumold, the laboratory mechanic, was shown embedded in the main floor of the laboratory. After a general inspection of the laboratory the visiting group gathered in Marvin Hall to hear a lecture by Prof. Frank L. Brown, member A.S.M.E., head of the applied mechanics department at Kansas University, entitled "Polarized Light and Its Applications."

On May 9 in Marvin Hall, Weldon Mooney, president, Mooney Engineering Company, Kansas City, Mo., spoke on "Valves and Their Applications." His talk was illustrated with several drawings produced by the Leslie Company, Lyndhurst, N. J. Plans for a picnic and an inspection trip in the future were discussed.

Lafayette College Branch

On May 14 a technical meeting was held at which E. A. Fayer, vice-president, presided. Wm. A. Cole, president and general manager of the DoAll Reading Company, gave a lecture on "Precision Instruments," supplemented with excellent illustrative slides. His talk covered the economy, accuracy, and versatility of precision measuring instruments and gage blocks made by his company. Following the lecture there was an informal intermingling of the students, faculty members, a few of the local professional engineers, the speaker, and his assistants. Actual gage blocks and measuring instruments were offered to those present for inspection. Through the co-operation of Mr. Cole and his assistants the students acquired considerable knowledge about gage blocks and precision measuring instruments in many of their phases.

University of Maryland Branch

At the meeting on May 1 in the Arts and Science Auditorium, Everett E. Hart, chief of the experimental flight-test division, Engineering and Research Corporation, Riverdale, Md., spoke on "The Development, Performance, and Future of the Ercoupe." Mr. Hart holds a commercial pilot's license and an instructor's license in both single and multiple engines and land and seacraft, and has been flying since 1927. Before going to Engineering and Research Corporation, he was an engineer and flight instructor and flight-test pilot with the Parks Air College, St. Louis, Mo. He has been active in the development and testing of the Ercoupe. In his talk Mr. Hart discussed the advantages of the two-control type of aircraft with its nonspin characteristics, and the tricycle landing gear making safe landings possible at all times. He traced the history of its development and explained its performance during flying and landing. He stated that it may be possible in the future to develop a single-control aircraft. Prof. John W. Jackson, junior A.S.M.E., honorary chairman, announced that Bernard Lubarsky, student chairman, had been selected to receive the junior A.S.M.E. membership award of the Washington section of A.S.M.E.

On May 16 in the Engineering Building plans were discussed for attending the A.S.M.E. Convention at Bucknell University. The chairman, Bernard Lubarsky, voiced for the members, appreciation of the work done by Prof. J. W. Jackson in the preceding year for the branch. Officers were elected for 1946–1947 as follows: Edward R. Talone, chairman; Burton L. Banks, vice-chairman; Ronald E. Bowles, secretary; Boyd Waters, treasurer; Prof. J. W. Jackson, honorary chairman.

Massachusetts Institute of Technology Branch

On April 17 the Glenn L. Martin Company" sound film "PBM-3 Wing Destruction Test's was shown. The film described the ultimate wing-strength test made by the Glenn L. Martin Company on the Navy's patrol bomber, The Mariner. The entire mechanical-engineering faculty were guests at this meeting.

On May 4 the branch sent a delegation to the Rhode Island State College at Kingston,

STUDENT BRANCH OF UNIVERSITY OF MINNESOTA

(*Left to right, back row:* Setzer, Anderson, Honebrink, Kobett, Von Bırgen, Eakle. *Fourth row:* Gilmer, Thompson, Soroko, Bradburn, Tedrow, Stanton, Taylor. *Third row:* Miller, Nordeen, Jurek, Hillyard, Teders, Kruger. *Second row:* Day, Gottstein, Takahashi, Bunker, McCabe, Hedges, Petre. *Front row:* Lathrop, Murphy, Anderson, Carr, Kasai, Okuma.)

R. I., for the New England Regional A.S.M.E. conference. Tech competed for awards at this meeting. Prof. Harry Majors, Jr., accompanied the group, as Professor Murray was unable to go.

On May 21 Prof. J. H. Keenan spoke on "Jet Propulsion and Rocket Power." He said that the first attempt at jet propulsion that worked was the airplane built by the Comproney Company in Italy. The main disadvantage of this system was that it was too heavy. Professor Keenan explained that rockets as military weapons fell into disuse shortly after the Revolutionary War. The following were elected to office for the summer term: Bernard Morrill, chairman; Narsinh G. Morarji, vice-chairman; Benny Z. Ostrovsky, secretary-treasurer.

Michigan State College Branch

A meeting was held on May 14 at the home of Prof. L. C. Price, at which time the following officers were elected for the coming year: Robert J. Williams, chairman; Donald J. Clark, vice-chairman; William J. Krupp, secretary; Chester Rupp, treasurer. Harney Wilson, a student member, gave an interesting talk on aluminum forging. After the program refreshments were served by Mrs. Price.

On May 28 the members met at the Ottawa Street Power Plant in Lansing, Mich. This is a new and modern plant, 16 stories high. A complete and interesting trip was taken through the entire plant, with details explained by plant officials.

University of Michigan Branch

On April 10 a meeting at Michigan Union was called to order by Richard J. Broadman, president. David Van Tuyl, vice-president, announced that Prof. F. W. Wilson, member A.S.M.E., would speak on "Opportunities for Mechanicals in Processing Industries" at the next meeting. Prof. H. E. Keeler, member A.S.M.E., gave a talk on the details of a power plant, and following his address, the members went on a tour through the University power plant.

The meeting on April 24 was called to order by vice-president David Van Tuyl. Prof. Frank W. Wilson, of the mechanical-engineering department, was the speaker. His topic was "Opportunities for Mechanical-Engineers in Process Industries." Professor Wilson said that a process plant deals with the manufacture of solids, liquids, or gases, and that chemical, cement, and synthetic rubber plants were examples of process plants. The speaker said that the engineer must look for two causes when trouble occurs in a plant; (1) he must find what is causing trouble from the process end; and (2) he must find what is causing trouble from the mechanical end. The mechanical engineer's functions in a process plant are to draw plans, know what should go into them and what shouldn't, and to work on development of new special machinery for special jobs. Professor Wilson's talk was illustrated with slides obtained from the Blaw-Knox Company.

University of Minnesota Branch

The first meeting of the spring quarter, held on April 3, was a membership rally. Twenty-five students joined at this meeting. The new officers elected during the winter quarter presided. They are: A. O. Lee, honorary chairman; Richard Tedrow, chairman; Edwin Carr, vice-chairman; Fred Bentz, secretary, and Frank Nordeen, treasurer.

Ten members of the branch were delegated to attend the annual meeting of the 5th District of the Student Branch Societies held at Notre Dame on April 29 and 30. At this meeting Arnold Ender, one of the new members, recently returned to the University from the Armed Services, presented his paper on the Gyro Fluxgate Compass.

At the May 1 meeting in University of Minnesota Student's Union, a report was given by the delegates to the Notre Dame meeting, and plans were discussed for future inspection trips of local industrial plants.

Missouri School of Mines & Metallurgy Branch

A short business meeting was held on May 15 for the purpose of electing new officers for the summer semester. Those elected were: Al Olivares, chairman; T. Kallemeyer, vice-chairman; E. Lindquist, secretary; J. Krath, treasurer. Mr. Kilpatrick will continue as honorary chaïrman for the coming semester. The new chairmen then appointed a committee on entertainment and programs, consisting of: Elmo Lindquist, chairmen; Fred Springer, R. Weise, and William Dunham. A short talk outlining the progress of the A.S.M.E. on the campus since 1928 was given by Dr. A. Miles, head of the mechanical engineering department. Dr. Miles pointed out the advantages of being a member, and the expectations of the future proceedings of the organization. At the present time the mechanical engineering department has the largest enrollment on the campus and the branch looks forward to very interesting meetings.

New Mexico State College Branch

An inspection of the El Toro cement plant was the feature of the March 3 meeting. Twelve students were shown through the plant by a foreman who explained each individual process. The entire trip consumed four hours.

On March 26 a technicolor film was shown, product of the New Jersey Zinc Company, entitled "Die-Casting." After the program an informal discussion was held concerning program plans for the rest of the semester.

Northeastern University Branch

The annual banquet was held on May 14 in the University Commons. The speaker, Arthur Makas, of the class of 1940, and now a research physicist for the Polaroid Company of Cambridge, Mass., gave a talk on "Present-Day Developments by Polaroid." Pictures, slides, and demonstrations illustrated the talk, and Mr. Makas showed samples of Polaroid sheets and lenses. Robert Saumsiegle of the class of 1948, and chairman of the student chapter, was given two awards; the first, a certificate from the A.S.M.E. parent chapter for having been selected the outstanding member of the Northeastern chapter; the second a prize of $5 for ably representing the University at the student-chapter convention held at Rhode Island State University, with his paper on "Permanent Mold Castings." The awards were made by Prof. Frederick A. Stearns, faculty adviser. Entertainment was furnished by two N. U. co-eds, Lois Brady, 1949, and Frances Lezberg, 1950. Special guests were: Prof. Alfred Ferretti, Prof. Joseph Zeller, Prof. Chester Wolowicz, and Albert Schmieder, all of the mechanical-engineering department. Professor Stearns, faculty advisor, assisted in the reception to the guests.

At the May 15 meeting in room 200R Richards Hall a film entitled "The Miller That Uses Its Head" was shown by Arthur Nichols, representative of W. H. Nichols and Sons. Mr. Nichols is in charge of tool designing and production and is a descendant of the original founder of W. H. Nichols and Sons. In his talk he pointed out some of the advantages that would result from a miller of this sort for the small machine shop which has limited capital and facilities. In a small shop, he explained, it can perform many of the functions of the more specialized machine, with a minimum cost for equipment. He discussed some of the newer developments in materials used in the design of hand millers, particularly Meehanite, a form of cast iron with exceptional elasticity.

New York University (Evening) Branch

A joint meeting of the N.Y.U. evening student branches of A.S.M.E., A.I.E.E., and A.S.C.E. was held on May 22 in the Green Room, East Building, N.Y.U., Washington Square, New York, N. Y. A motion picture entitled "The Shape of Things To Come" was shown. This is a sound and color film which illustrates the methods and equipment used in compression, injection, and transfer-molding plastics. The film was made in the plant of the Boonton Molding Company. The members of the branches then separated into their respective groups. Election of officers for 1946–1947 of the A.S.M.E. student branch was held, resulting in the following: Willard Wyler, chairman; Robert Ellis, vice-chairman; David Solon, secretary; and A. Francis Baker, treasurer.

"Open House Day" was held by the college of engineering, evening division, on the University campus on May 25. Students conducted the guests through the laboratories and explained the apparatus. A baseball game was held in the afternoon, N.Y.U. playing St. John's, with a score of 17–3 in favor of the former. Refreshments after the game were served in Mess Hall, South Field.

Rice Institute Branch

On the afternoon of May 10 thirty members of the branch visited the plant of Sheffield Steel Company of Texas, located near Houston. Arrangements had been made through George Miles, personnel director of Sheffield Steel Company. W. B. Bates, sales engineer, H. A. Marshall, assistant personnel director, and E. W. Smallwood, chief of plant protection, conducted the group past the open-hearth furnaces, through the rolling mill, the structural mill, the wire department and the blooming mill. The group also inspected the manufacture of nails and wire fencing. An interesting feature was the modern way in which the operations were performed. Much of the heavy equipment was electrically operated and the furnaces were fired with gas and oil. As a climax to the inspection the group saw one of the furnaces tapped and the steel poured into molds.

University of Rochester Branch

A special business meeting was called by W. B. Harison, chairman, on May 1, in the Engineering Building, for the purpose of securing an appropriation toward expenses for those attending the Rhode Island Regional meeting. A motion was made that an amount of $30 be appropriated. This was voted upon and carried.

At the regular monthly meeting on May 7 in Rush Rhees Library, James Kinney told of the annual A.S.M.E. Student Convention which he attended at Rhode Island State College on May 4. He urged more students to attend and to present papers at the convention next year. Election was held for two members to represent the A.S.M.E. on the Engineers' Council. Plans for a picnic were discussed.

South Dakota State College Branch

Election of officers was held at the May 8 meeting in the Engineering Building, as follows: Eugene Case, president; Glenn Cherry, vice-president; Robert Nelsen, secretary-treasurer; Kenneth L. Wetterberg branch executive member; Lee A. Amidon, honorary chairman. A film on the subject of heating and energy was shown.

University of Southern California Branch

At the April 24 meeting in the Cinema Building 11 membership applications were accepted. A movie entitled "The Building of a Tire," loaned by the Firestone Tire and Rubber Company, was presented.

On May 3 in the Student Union building a short business meeting was conducted by chairman Wm. Miroff. The dean of the college of engineering, Robert E. Vivian, was introduced, and spoke briefly on the present and future plans of the engineering school. A. R. Weigel of the Los Angeles Section A.S.M.E., discussed plans for future co-operation between the section and student branches of A.S.M.E. in Los Angeles. Mr. Weigel then introduced V. L. Peickii, junior A.S.M.E., who explained the organization of the A.S.M.E., and the functions of the various divisions and committees. E. Vernon Welch of the Owens-Corning Fiberglas Company, gave a talk on "The Development and Uses of Fiberglas." Many samples were shown, and an interesting discussion was held after the talk.

Texas A.&M. College Branch

On March 18 at a meeting held in the Mechanical Engineering Building, new officers were elected as follows: James H. Beard, chairman; L. A. Larrey, vice-chairman; Watson Keeney, treasurer; Hugh D. McMillan, secretary.

A tour of inspection was made on April 2 of the college power plant. Professors Brewer, Long, Simmang, and Files, of the mechanical-engineering department, conducted this very interesting tour. Inspection was made of the power-generating equipment, steam-generating equipment, and cooling tower.

Harry Acreman, executive secretary of the Texas Federation of Labor, was the speaker at the April 23 meeting in the Mechanical Engineering Building. His talk on "Labor Management Problems" was very timely, and in the discussion which followed many points on the subject brought out by questions from the audience, were explained more fully by Mr. Acreman.

On May 7 W. W. Finlay, vice-president, Guiberson Corporation, Dallas, Texas, lectured on "The Engineering Profession—A Look Into the Future." Mr. Finlay said that he felt the engineering profession must take an increasing interest in public affairs in order to "protect people from themselves," and that the engineer must be a leader in the society of tomorrow. A question period followed. The attendance of 78 was so unusually large that the meeting had to be held in a larger building than the one first selected.

Washington State College Branch

On April 18 in Room 110, Mechanic Arts Building, a meeting was held for the purpose of obtaining more members, and nominating and electing officers. After the nominations a ballot was cast and the following were selected for office: Pat O'Neil, chairman; George Medley, vice-chairman, Alvin Benjamin, secretary; Dean Ladd, treasurer. A program committee was appointed by the chairman, consisting of Storms, Lee, and Robinson. An open discussion concerning

NORTHEASTERN UNIVERSITY STUDENT BRANCH AT THE ANNUAL A.S.M.E. STUDENT-BRANCH BANQUET, MAY 14, 1946 future programs was held, following the presentation of a letter from the Inland Empire Section, A.S.M.E., offering prizes for a paper to be presented by students on a subject of interest to mechanical engineers; the prizes to be first, a junior membership in A.S.M.E. and $5., and second, a junior membership in A.S.M.E.

At the April 30 meeting Pat O'Neil, chairman, introduced Mr. Parker, honorary chairman who gave a short talk on the future possibilities of the branch. He said that activity during the coming summer session depends upon the present members who are willing to carry on the work, and also upon the number of new students enrolled. He announced his plans to attend the meeting of A.S.M.E. honorary chairmen in Seattle, on May 6. A field trip to Coulee Dam was discussed and the trip planned for May 11. A committee consisting of Medley, Lee, and Wise was appointed to arouse interest in this trip. A film was then shown entitled "Manufactured Abrasives."

At the meeting on May 21 in Room 110, Mechanic Arts Building, Dean Sloan, department of mechanic arts and engineering, presented the recent changes in the general college requirements and their probable effect upon the schedule of the engineering students. Under the new policy the choice of major study will be delayed until after the first year. It was suggested that plans be made to keep the engineering reading room open during the evening to permit students to avail themselves of books and periodicals. The motion was made and carried that the next meeting will be early in October of this year.

Worcester Polytechnic Institute Branch

On May 22 the members visited the South Works, American Steel and Wire Company, Worcester, Mass., as guests of the Worcester Section, American Society of Metals. The portions of the plant visited were those dealing with the production of steel rod before fabrication into consumer goods. First came the steel mill, featuring four 95 NT basic open-hearth furnaces. Although no heat was poured during the visit, charging and melting operations were seen. Next came the soaking pits where the ingots were stripped of their molds and placed in furnaces to heat to working temperature. Following these was a reversing Bloomer, rolling 20 in. × 22 in. ingots to $5^{1}/_{4} \times 5^{1}/_{4}$ in. blooms. Immediately after was an 18 in. billet mill reducing the bloom to a 2 in. × 2 in. billet which was then cut to desired length and conveyed to cooling beds prior to storing. Finally, the reheated billets were fed from a furnace to a continuous, double-line rod mill to be rolled to size, coiled, cooled, and loaded into cars, ready for fabrication.

University of Wyoming Branch

At the meeting on May 8 in the Engineering Building Mr. Brandt reported on the student papers at Colorado University and the joint meeting of the students with the Denver Section of A.S.M.E. Harry House, chairman, reported on the round-table discussion held the previous Saturday at the Albany Hotel, by the student group who were present at the Rocky Mountain Group IX of student branches.

On May 25 in Engineering Hall a short business meeting was held. Future programs were discussed and a publicity committee was appointed. Toney Yugovich was named chairman. July 11 and Aug. 8 were chosen as probable dates for summer-session meetings.

Yale University Branch

On May 10 in the Dunham Laboratory, Prof. Everett O. Waters, member A.S.M.E., of the Yale School of Engineering faculty, spoke on "The Purpose of the A.S.M.E. Boiler Code." He explained the organization of the boiler code committees, and the nature of the work done by the committees. Forty members and guests were present.

On May 16 a group of student members went to Ansonia and Derby, Conn., for a conducted tour through the plants of The Farrel-Birmingham Company, manufacturers of special machinery.

Dr. Lionel S. Marks, Fellow A.S.M.E., professor-emeritus of mechanical engineering, Harvard University, was the speaker at the meeting on May 24 in Dunham Laboratory. Dr. Marks spoke on "Recent Developments in Jet Propulsion and Rockets." The talk, which was accompanied by slides, described types of jet engines, the German V2, and buzzbomb, and gave possible future applications of jet propulsion and rockets, as well as their limitations.

On May 31 in Dunham Laboratory, James Partington, Fellow A.S.M.E., of the American Locomotive Company, gave a talk on "Steam, Electric, and Diesel-Electric Locomotives." He traced the development of each type of locomotive, giving pertinent data concerning the engines and their applications in railroading. The talk was accompanied by slides.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York
8 West 40th St.

Chicago
212 West Wacker Drive

Detroit
109 Farnsworth Ave.

San Francisco
57 Post Street

MEN AVAILABLE[1]

Executive Engineer, graduate mechanical, 26 years' experience light- and heavy-machine manufacturing; tool, die and machinery design; plant engineer, superintendent factory of 1000 employees. Age 48, married. Good health. Desires administration or chief engineer's position. Me-61.

Mechanical Engineer; 27, married; with four years' experience marine and automotive Diesel operation, maintenance, and repair; one year marine steam operation and maintenance; one year aircraft-production experience. Desires sales, service, or supervisory position with progressive concern; Me-62.

Mechanical Engineer, army officer, age 34, married. Experienced mechanical-electrical equipment. Desires promising position where background of design, research, and co-ordination will be of advantage. Location preferred Southwest. Me-63.

Sales or Engineering Executive, age 47, married. Twenty-one years' experience sales, design, research, university teaching, consulting on steam and Diesel power plants. Available after July 1. Location preferred, California. Will travel. Me-64.-465-D-3-San Francisco.

Mechanical Engineer, graduate, age 32, single. Executive aptitudes and ability, $5^{1}/_{2}$ years' ordnance procurement experience, including 3 years in tank, combat vehicle, maintenance, and tools. Seeks opportunity in automotive tool manufacturers' purchasing department or phase of industrial management. Available immediately. Preferred location New England or Middle Atlantic States. Me-65.

Graduate Engineer, mechanical, 28, married. Eleven years' experience machinist apprentice, draftsman, factory engineer on electric motors, sales engineer for powdered-metal parts manufacturer. Desires sales engineering position, or managerial assistant. Me-66.

POSITIONS AVAILABLE

Mechanical Engineer, 22–30. Will set up and supervise air-conditioned quality-testing laboratory, develop testing methods and standards, analyze findings, recommend improved manufacturing methods, design machinery modifications and new equipment to produce highest quality in plants fabricating corrugated paper boxes. Salary $2400 to $4000. Indiana. R-3459.

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[1] All men listed hold some form of A.S.M.E. membership.

MANAGERS, 40–50, chemical or mechanical engineering graduates or equivalent, with 5 to 10 years' experience as works manager or other responsible position in a plant of about 1000 employees; varied experience on manufacturing side of process industry such as drugs, chemicals and oils, preferably packaged consumer goods. Must have knowledge of production, processes, industrial engineering, and low-cost operation. $12,000–$15,000 year. New York metropolitan area. W-7155.

MECHANICAL ENGINEER, 30–40, to supervise drafting room, shops, and field work connected with experimental installations, as well as the design and construction of pilot-plant units for chemical and metallurgical processes. Must be able to work with others on planning and layout of pilot plants. Pennsylvania. W-7173.

PROJECT ENGINEERS, preferably mechanical graduates, with 10 to 15 years' electronic experience, to design and develop computing devices. $8000–$10,000 year. Northern New Jersey. W-7178.

MANAGER of industrial department for Chamber of Commerce. Should be engineering graduate, preferably chemical, electrical, or mechanical, and possibly having some experience with a chamber of commerce, railroad, or public utility. About $5000 year to start. Louisiana. W-7180.

CIVIL ENGINEERS. (*a*) Superintendents. (*b*) Assistant superintendents. (*c*) Inspectors. Must have had at least 3 years' experience in field work on building construction. Salaries: (*a*) $5000–$6000; (*b*) $5000; (*c*) $2400–$4000 year. New York, N. Y. W-7202.

ENGINEERS. (*a*) Manufacturing executive, 38–45, with management experience, practical imagination, high character, as well as executive ability. Any experience in iron foundry would be helpful. $10,000–$12,000 year. (*b*) Welding engineer thoroughly trained in all types of welding engineering of both light-steel and heavy-plate work, versed in production methods, and with ability to lead an organization. $7500–$9000 year. Write giving full details of experience, references, salaries received, etc. Pennsylvania. W-7211.

SALES ENGINEERS, two, preferably young, for valve manufacturer. Ex-servicemen who have had engineering or sales experience would qualify. Considerable traveling. Salary plus expenses and bonus. Territories: one for Chicago area and other for northern New York. Headquarters, upstate New York. W-7223.

CHIEF INDUSTRIAL ENGINEER, graduate, 30–35, to have complete responsibilitity of administration of wage-incentive system, job-evaluation program, manufacturing-methods improvements, plant layout, and standard-procedure specifications for leading manufacturer of household furniture. Must be capable of assuming leadership and supervision of twelve persons. Good salary and opportunity. North Carolina. W-7232.

MECHANICAL ENGINEER experienced in hydraulic designs. Must be able to visualize and develop three-dimensional shapes on drawing board, such as Francis turbine wheel blading, axial or conical pumps or compressors; also aeronautical shapes and preferably with knowledge of calculating speeds and centrifugal stresses in disks. Upstate New York. W-7238.

INDUSTRIAL ENGINEER, 26–35, graduate of industrial engineering or business administration, with knowledge of motion and time study, wage-payment methods, job evaluation, standard costs and cost control, as well as layout and material handling. Must have minimum of 3 years' experience. $3600 year. Northern New Jersey. W-7245.

RESEARCH ENGINEER, mechanical, preferably experienced, for research and development of new equipment for the forming, handling, and decorating of china tableware. Need not necessarily have experience along this line but must have demonstrated genius for invention and design by having been responsible for design and development of mechanical equipment. From $5000 year. West Virginia. W-7247.

MECHANICAL ENGINEER, with 8 to 10 years' experience in design, preparation of plans and specifications, and the construction of Diesel-electric generating plants. Some traveling. $4500–$5200 year. Write giving experience and references. North Carolina. W-7268.

DIVISION STAFF ENGINEERS, two, mechanical graduates. Must have professional engineer's license and preferably with 10 to 15 years' experience in design, specifications, and operation of chemical or food-process equipment. Work divided between administration and engineering. $7500 year. Locations, one for Indiana and the other for New York, N. Y. W-7274.

ENGINEERS for old established firm manufacturing woven woolen materials. (*a*) Manufacturing engineering director, 35–45, mechanical graduate, with 10 years' experience in process and equipment design, facility layout and appraisal, 5 years of which was directing such activity. Will be in charge of process equipment and facilities planning; administer applied research and development of these fields; improve manufacturing processes and equipment, etc. Salary open. (*b*) General manufacturing superintendent, 30–40, graduate, with good knowledge of and successful experience in running sizable manufacturing organization, particularly in woolen textile industry. Will supervise yarn spinning, dyeing, loom setting and weaving, and finishing operations. $10,000 year. New York State. W-7280.

CHIEF ENGINEER for separate machine division of steel company, preferably experienced in machine-tool design and with knowledge of precision bearings. $15,000 or more, depending upon qualifications. Eastern Pennsylvania. W-7284.

DEVELOPMENT ENGINEER, having training and experience on aerodynamic problems. Background as physicist would be valuable. Project is for study and development of ram-jet and pulse-jet engines and devices. Opportunity for qualified man to work in this field under ideal conditions. D-2753.

Southern Library to Have Copy of United States Patent Office Files

IF THE present plans of the Georgia School of Technology are successfully carried through, southern engineers and scientists will have available on the campus of the School a complete file of American patents, duplicating the file at the United States Patent Office, Washington, D. C.

The first shipment of current patent records and drawings has already been received from Washington, D. C. In the near future all patent information dating back to 1925 may be available. An effort is being made by the School to obtain all or a greater part of the files of patents granted prior to 1925.

The availability of patent information in the library of the Georgia School of Technology will make it unnecessary for *local* engineers and inventors to make long trips to Washington for patent information.

American Rocket Society Elects Officers

THE American Rocket Society has announced that Lovell Lawrence, Jr., rocket engineer and president, Reaction Motors, Inc., has been elected president of the Society.

Other officers elected were: Roy Healy, vice-president; G. Edward Pendray, secretary; Louis Bruchiss, editor of *The Journal of the American Rocket Society*, and Dr. Samuel Lichtenstein, treasurer.

In October, 1945, the American Rocket Society became affiliated with The American Society of Mechanical Engineers.

A.C.S. to Meet in Chicago, Ill., Sept. 10 to 14, 1946

THE semiannual meeting of the American Chemical Society will be held in Chicago, Ill., Sept. 10 to 14, 1946. The Fourth National Chemical Exposition will be staged at the Chicago Coliseum, Chicago, Ill., as a part of the A.C.S. semiannual meeting.

Proceedings of Textile Division Meeting Available

THE A.S.M.E. Textile Division has announced that the Proceedings of the March 15, 1946, meeting of its Lubrication Committee has been completed and are available at $1 per copy from A. B. Studley, vice-chairman, A.S.M.E. Textile Division, SKF Industries, Inc., 10 High Street, Boston, Mass.

The Proceedings covers deliberations of the Lubrications Committee on the formulation of a standard to be used for identifying lubricants used in the textile industry.

R. D. Brouwer, New Departure Division, General Motors Corporation, is chairman of the Lubrications Committee of the Division.